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of an
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SMALL EXPENSE

IPLETE INSTRUCTIONS FOR OPERATING

EDERICK COLLINS

HOW TO TAKE CARE OF AN AUTOMOBILE AT SMALL EXPENSE

By A. Frederick Collins

- The Book of Wireless
- The Book of Stars
- The Book of Magic
- The Book of Electricity
- Gas, Gasoline and Oil Engines
- The Amateur Chemist
- The Amateur Mechanic
- How to Fly
- The Home Handy Book
- Keeping Up with Your Motor Car

D. APPLETON & COMPANY
Publishers New York

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HOW TO TAKE CARE OF AN AUTOMOBILE AT SMALL EXPENSE

WITH COMPLETE INSTRUCTIONS FOR OPERATING

REPAIRS AND HOW TO MAKE THEM

BY

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A. FREDERICK COLLINS

MEMBER AERO CLUB OF AMERICA

AUTHOR OF "THE BOOK OF WIRELESS," "THE BOOK OF ELECTRICITY," "THE HOME HANDY BOOK," ETC.

FULLY ILLUSTRATED

D. APPLETON AND COMPANY

NEW YORK LONDON

1920

Printed in the United States of America

TO MY NEPHEW

RAYMOND SAMUEL ZEITLER

INVENTOR—DESIGNER—BUILDER

A WORD TO YOU

Everybody else rides, so why don't you?

This is the age of power, wheels, and speed, and you ought to *belong*, for the riding is fine.

To own a motor car means that you have increased the measure of your life tenfold, not by tacking on so many more years to those you have already lived, but by living that much faster while you do live.

With a car you can go everywhere and see everything, and this takes you out of the rut of an ordinary human being and puts you into the class of the superman—takes you on the great broad highway where you can see a never-ending panorama of the glories of nature and the handiwork of her puppets. And this is indeed living.

Again, there is your health. When you motor you breathe in great lungsful of oxygen—that wonderful magnetic gas which, if it is not life itself, is the great sustainer of life; and this helps to give you physical strength, to preserve your mental poise, and to increase your power so that when you get down to the routine of business again you are a regular dynamo for work.

These are the good things about owning a motor car, and now let's see what's the matter with it.

You may have thought that a car is beyond your means to buy and beyond your salary to keep up, and so it is apt to be unless you know, in the first place, how to buy one; in the second place, how to treat it after you get it; and in the third, the right thing to do

when something goes wrong with it at whatever old place it may happen to stall.

Not to know these things will make a car a burden to any man of ordinary means, but if you will take a tip from one who is *in the know*—I have examined the working specifications of 159 different makes of cars—you will find that it is almost as cheap to ride on air-inflated tires as it is to walk on rubber-heeled shoes, and it's a lot more pleasant, too.

So now get in with me for a demonstration, and if the car rides easy and it is all that you think it ought to be for the money, take the following twelve easy lessons and be glad.

A. Frederick Collins.

Biltmore Chambers,
Boston, Mass.

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HOW TO TAKE CARE OF AN AUTOMOBILE AT SMALL EXPENSE

CHAPTER I

HOW TO BUY A MOTOR CAR

I do not know whether you are a Christian or a scientist or both of these x and y quantities equated to *zero* but I am firm in the belief that if you want a thing hard enough it will be yours for the thinking.

It's a trite saying that "where there's a will there's a way," but never before in the course of human events has it been so strikingly exemplified as in the case of a fellow who wants a motor car and of his ability to find the means to get one.

The Dominant Idea.—So let's suppose that you have had a burning desire to own a car and enjoy life like your neighbors or to use one in your business like your competitors.

Now when this craving has seared into your soul deep enough it develops into a mental abnormality which psychologists call the *dominant idea,* that is, your every waking thought will automatically influence, control and direct your mental activities to the end that your wish may be fulfilled, and the net result of it all is that you *will* finally own a car.

The whole process is akin to faith cure, as the psychical treatment of diseases is called, but you don't need to care a continental how it is brought about as long as you get the coveted thing.

Ways to Buy a Car.—Now there are several ways to buy a car—I say *buy* because it is the only scheme I know of to get one, for it's a thing you can't borrow—though you can borrow the money with which to buy one, it is quite unlawful to steal one and I have yet to hear of the lady or gent who accumulated enough green trading stamps to swap for one.

You probably know as well as I do that if you have any amount of money from $345 on up with the sky as the limit you can go out and be separated from it in an hour's time and bring the thing of beauty and joy until something goes wrong with it, home with you. This is the easy don't-give-a-care way. But if you haven't the immediate wherewithal two methods are still open for you to buy a car just the same, and these are (1) to mortgage your bungalow and (2) to buy it on time payments—the latter plan being the same in principle as that on which Ansonia clocks and Smyrna rugs are sold by peripatetic agents.

As to mortgaging the old homestead to buy a car, well, that's a *tremenjous* proposition which you and the wife will have to decide, but when it comes to the time payment plan that is an entirely different matter and more will be said about it anon.

Kinds of Cars to Buy.—Generically speaking, there are two kinds of cars to choose from and these are (1) new ones and (2) second-hand ones.

All other things being equal it is always the best plan to buy a new car if you can afford it, but still there are times when it is good business to invest in a used car, but as the purchase of such a car is a weighty problem it will likewise be touched on a little later.

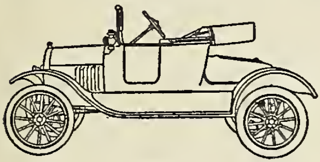


FIG. 1

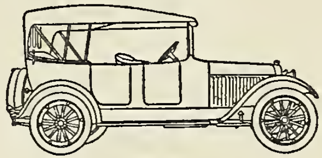


FIG. 2.

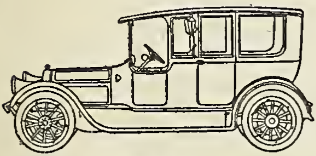


FIG. 3.

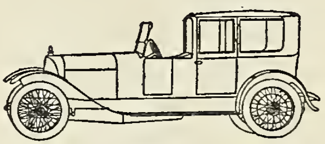


FIG. 4.

FIG. 1.—The Ford Runabout. The cheapest car made. Price $345, 2 passenger, 4 cylinder, 20 horsepower.
FIG. 2.—The Chalmers Touring Car. A fine example of a low priced car. Price $1,050, 5 passenger, 6 cylinder, 30 horsepower.
FIG. 3.—A Pierce-Arrow Limousine. As good a car as need be built. Price $5,200, 5 passenger, 6 cylinder, 38 horsepower.
FIG. 4.—An F. R. P.[1] Brougham. A car fit for a king and his queen. Price $9,000, 5 passenger, 6 cylinder, 52 horsepower.

On Buying a New Car.—In the very beginning this much is certain—you can't go wrong if you buy a new car.

Never before in the history of the automobile industry have manufacturers so felt the need of putting the very best materials and workmanship into their cars, because

[1] Finley Robertson Porter.

of all the varied products used by the intelligent public today the motor car is the most widely discussed.

A man may buy a turkey that he can't masticate, or a suit of clothes that shrinks in the rain, or, in the polite vernacular of automobile row, he may get *stung* in any one of a hundred ways and soon forget all about it, but just let the smallest accident happen to his car and he will tell everybody he meets about it for the rest of his natural life.

This untoward *knocking* has been a large factor in stimulating manufacturers to make good cars, and the result is that the cars of all the makers can be depended upon about in proportion to the price you pay.

Next to buying a car of an old, true and tried maker, put as much money into it as you are able, for almost without exception the more a car costs the greater satisfaction it will give you, not only in its wearing qualities but in its riding properties, to say nothing of its higher-toned appearance.

Buying a Cheap Car.—Should your bank roll range from $345 to $600 you will have a choice of two or more styles and of at least nine makes of cars. The following table gives the make of car, the price of it and the place where the factory is located:

Table of Cars Costing Less Than $600.

Name of Car.		*Price.*	*Where Made.*
Ford Model I	Runabout	$345.	Detroit, Mich.
	Touring	360.	
Emerson		395.	Kingston, N. Y.
Chevrolet		490.	Detroit, Mich.

Name of Car.	*Price.*	*Where Made.*
Saxon B 5 R	Roadster $495.	Detroit, Mich.
Metz 25	545.	Waltham, Mass.
Moore H G M	550.	Minneapolis, Minn.
Monroe M-3	565.	Pontiac, Mich.
Harroun	595.	Detroit, Mich.
Maxwell 25-4	595.	Detroit, Mich.

Before you buy one of these low-priced cars it is an excellent plan to get the *literature* on all of them. If you live in a city or even a town you will quite likely find a dealer, or at least an agent, who will supply you, and if you live in the country send to the manufacturers direct for it.

My idea of buying a low-priced car is that one is about as good as another and so the only features that are worth considering are (1) the price you want to pay and (2) the car you like the best.

Any of the above cars should give you good service for two years, or even longer, and you can then trade it in and get a new car of the same make, or sell it and try a car of some other make. In my opinion it is a great mistake to trade in a car at the end of the first year for it should then be in the very pink of condition.

Since misery loves company it ought to cheer you up a bit to know that many of these cars are made of better materials than a lot of the medium-priced cars that were put on the market in 1910, and which have since gained in reputation and increased in price. Buy any of the above cars and you will in all events get your money's worth.

Buying a Medium-Priced Car.—If you can

spend from $600 to $1200 for a car you will have over 60 different makes to choose from, and these include more than a dozen well-known names.

These better kinds of cars should stand up well for four or five years and by that time you will either not need a machine or you will want a new one, especially if you are a stickler for style—though the design is not as apt to change either as fast or as radically in the next few years as it has in the past, but of course improvements will always be in order.

To read what each advertising man has to say about all of the good points of his company's car and all of the reasons why you ought to buy it would take half a lifetime, hence the best way is to pick out a car at your price, choose a style that you like, a type of body that meets your needs, a make that you know to be good, and see to it that the upholstery is twilled and not tufted and you won't go wrong.

Buying a High-Priced Car.—Doubtless you will say that a $1200 car is far from being high-priced, but, on the other hand, you will agree that a $9000 car is *some* expensive. One good thing about buying a high-priced car is that you can have your choice of 75 different makes between these two extremes.

When you buy a car costing between $1500 to $2000 you will have one that would do a King proud, but there are others. From $2500 on up you can have your pick of cars that include such famous makes as the Stutz, Lozier, Packard, Marmon, Winton, Pierce-Arrow, Locomobile, Simplex and the F. R. P.

These and other high-priced cars are built of the fin-

est selected and most carefully tested materials and they are the last word in all that goes to make up perfectly appointed cars.

What's What in Car Bodies.—As an aid in helping you to select the right kind of a body the following table, which gives the different types of car bodies as officially defined by the Society of Automobile Engineers, is appended:

Roadster.—An open car seating two or three. It may have additional seats on running boards or in rear deck.

Coupelet.—Seats two or three. It has a folding top and full height doors with disappearing panels of glass.

Coupé.—An inside operated, enclosed car seating two or three. A fourth seat facing backward is sometimes added.

Convertible Coupé.—A roadster provided with a detachable coupé top.

Clover Leaf.—An open car seating three or four. The rear seat is close to the divided front seat and entrance is only through doors in front of the front seat.

Touring Car.—An open car seating four or more with direct entrance to tonneau.

Salon Touring Car.—A touring car with passage between front seats, with or without separate entrance to front seats.

Convertible Touring Car.—A touring car with folding and disappearing or removable glass sides.

Sedan.—A closed car seating four or more all in one compartment.

Convertible Sedan.—A salon touring car provided with a detachable sedan top.

Open Sedan.—A sedan so constructed that the sides can be removed or stowed so as to leave the space entirely clear from the glass front to the back.

Limousine.—A closed car seating three to five inside, with driver's seat outside, covered with a roof.

Open Limousine.—A touring car with permanent standing top and disappearing or removable glass sides.

Berline.—A limousine having the driver's seat entirely inclosed.

Brougham.—A limousine with no roof over the driver's seat.

Landaulet.—A closed car with folding top, seats for three or more inside and driver's seat outside.

Buying a Car on Time Payments.—Nearly all dealers will sell you a car on what is called the *deferred payment plan,* that is, you pay 25 to 50 per cent down and the balance in eight or twelve equal monthly payments, and you give your notes, promissory or secured, at 6 per cent interest, for the balance.

Now the right way for you to buy a car at the present time is on the deferred or time payment plan, and this applies to you, gentle reader, whether you are a $20 a week grocery clerk or a millionaire, as you will plainly see if you will but read a little farther.

The Opulent Man's Way.—And why, you may wonder, should you with a barrel of cash on hand or in the banks, or better, its equivalent in stocks, bonds and other securities, buy a car on the deferred payment

plan and pay interest instead of paying cash and, perchance, get a rebate.

But there's a reason and I hold it's a mighty good one. When you buy a car of a dealer for cash the moment he has your money and you have his car he loses interest in both you and the car. Should anything go wrong and you ask him to make it good, he will to all outward appearances be interested, but at heart it is a very negative interest and the result is that you are more than apt to get poor service and little or no satisfaction.

Now you may say it isn't fair and it isn't business for a man to act that way and while your premises in both cases are true still it is simply unadulterated human nature, and you can't change it, no, not even if you cut away that part of his thick ivory which presses against the convolution of his gray matter wherein resides his Christian training.

But what you can do is to circumvent it by taking the proper precautionary measures when you buy the car. That is to say, make the first payment the dealer requires and then give him your notes for the balance, making the first one payable three months from the date of purchase if possible.

Every maker and every dealer will tell you to run the car very gently at first because it is new, and that you must do so until the engine and other moving parts are *tuned up*. My idea is a little different in that when you get the car you ought to drive it at least 1000 miles a month, and by the time you have run it for the three months if there is any inherent defect it will be bound

to show up. Whatever happens to it see the dealer and you will find that he will take just as keen an interest in it as you do for he knows that unless he makes good and satisfies you that you will default in your payments for cause, and that he will have a second-hand car on his hands.

Having thus run up the mileage to or more than the limit cited and tested it out when the three months roll around and your first note is due, if the car is satisfactory, take up all your notes and you will have paid the same price as if you had laid down the full amount in the first place, plus a very small premium, and you will know that your car is a good one.

The Salaried Man's Way.—And what has just been said above applies equally as well to the salaried man who buys a car. Not only this, but the deferred payment plan has made it possible for hundreds of thousands of men and women in moderate circumstances to buy cars who could never have afforded them otherwise, just as the same plan has enabled these same thrifty, happy and independent folks to buy homes and to furnish them.

The idea that it is poor policy for a person to buy that which he hasn't the spot cash to pay for has, like Aristotle's teachings that interest is sinful—long since been knocked in the head; so too the idea that it is wicked for anyone who has to depend on his daily toil for his bread to own a car is fallacious in every sense of the word.

But what everybody has always admitted is perfectly all right and proper, though, is the pursuit of happi-

ness; this being true, let me say that there is no vehicle besides the motor car and the aëroplane with which one can so successfully pursue happiness; aye, what is more, it is one of the few ways in which one can actually catch up with it (unless something happens).

I don't need to tell you what a delight it is to spin smoothly and swiftly over long stretches of the countryside with those you love and who love you, stop at some quiet dell or by some babbling brook to eat your lunch and then roll up a comfortable mileage to get back home again. I tell you to do these things and to know nature is the finest kind of religion, and the motor car is a creed that has as many adherents, at least in spirit, as all the other formal religious beliefs put together. Go thou then and likewise hit the macadamized trail.

Buying a Second-Hand Car.—The market is glutted with used cars of every kind and vintage, and you can buy some of these at prices as small as the tires of a good car are worth, and then on up to figures that are unconscionably high for the junk you get.

Then there are all manner of people who have second-hand cars to sell from the individual owner who is leaving the city for a goal somewhere in France or a pole somewhere in the Arctics, to the regular used car dealer, and from the automobile broker to the high-grade companies who have what they are pleased to call *rebuilt cars.*

Now when you buy a second-hand car you are taking a far longer chance than you did when you bought the prehistoric quadruped of the *genus equus* in the long ago age that antedated Selden's first *self-moving wagon*

in 1878, and for a considerable time thereafter. In those days you could at least look at her teeth and *feel out* her good and bad points. But not so with an automobile, for while it may look well and run better on a demonstration there may be grave faults in it that neither you nor it will ever get over.

Nor does it do any good to have a machinist look over a car for the defects are usually hidden from view and the only way to know its precise condition is to tear it down, examine every part and then reassemble it; this of course is not practicable once in a thousand times, even if you were willing to pay for having it done.

Be mighty careful, therefore, in buying a second-hand car of anyone for you do so at your own risk, or *caveat emptor* as the bill of sale will read, which means in cold-blooded American *let the buyer beware,* and that you buy it *as is.*

Talk about injecting the *hypo* into an antediluvian *selling plater* to make her prick up her ears, take the kinks out of her knees and do a mile in something less than three minutes—why, it's mere child's play as against the way a professional dealer doctors up a *tin lizard* and handles the sale of it.

My advice is never to buy a second-hand car unless you are willing to spend an additional \$50 or \$100 on it to have it overhauled after it is yours for keeps.

With high-grade cars like the Packard, Pierce-Arrow, Winton, etc., you take a smaller chance because they are made of the best possible materials to begin with and if you are looking for service rather than style

any of these good cars that are less than five years old and can be bought for less than $500 is what I should call a bargain.

To buy a *rebuilt* car of some big and well known company is in my opinion entirely safe—probably because I have never had the actual experience of buying one in that particular manner—but in any case you will pay all that the car is worth.

Still sticking to my original premise if you will buy a new and tested make of car costing from $1000 to $2500 on the deferred payment plan you can't lose out.

CHAPTER II

LEARNING TO DRIVE YOUR CAR

I am taking it for granted that you have never driven a car before but I am also assuming that you have already bought a car and that the aforesaid car is a brand-new one.

Lessons from a Demonstrator.—This being the case, you are ready to take your first lesson from a *demonstrator;* that is, a man employed by the company to instruct a buyer how to run his car. You and he get into your car—they never teach you in a car that belongs to the company—and naturally he takes the wheel and you're off.

He drives you to some wide and quiet street where you will receive your first lesson. If you are a wise *gazabo* you will cross the palm of his hand right away with a $5 bill, for then he will take great pains to tell and show you about your car; his patience and ability as a tutor will be increased in the ratio of about 0 to 5, i. e., to infinity.

Now while the demonstrator is fully competent to teach you to drive the car at the same time if you know a little about it in advance he will be able to teach you in half the time and it follows you will be able to drive your car just twice as quickly. Hence it behooves you to read this book very carefully.

The Lessons.—In your first lesson the demonstrator simply shows you how to work the *clutch, brake* and *accelerator* pedals and use the *throttle, spark* and *gear shifting* levers.

The next lesson he lets you take the *steering wheel* and you throw the *clutch* in and out, shift the *transmission gears,* accelerate the *engine*—that is, you give it more gas—and learn to *brake* the car by means of the *service* and *emergency* brake levers.

In the third lesson, if you are an apt pupil, he teaches you how to turn around and to back up, and finally he goes over the car and shows you where all the *grease-cups* are, how to oil the engine, all about the *starting, ignition* and *lighting* systems and then he drives you to your *garage* and leaves the high-powered machine for you to get acquainted with.

Running the Car Yourself.—When you are alone together, so to speak, with your car, the best way is to get into it while the engine is *dead,* that is not running, and practice throwing the clutch in and out and working the brake and accelerator pedals; the main thing is to learn to push the clutch *out* every time before you throw the gear shift lever, for if you forget to do so you will *strip the gears,* which means that a few teeth will be broken off them.

If you will read the following chapters painstakingly you will know exactly how the clutch and transmission gears are made and how they work, as well as the *carburetor* which regulates the supply of gasoline and air that forms the explosive mixture, or *fuel mixture* as it is called, for the engine, and the *ignition*

system, which makes the electric sparks for exploding it.

Knowing the action and operation of these devices it will be easy for you to understand why and how the pedals and levers control them, and hence it will be almost second nature for you to manipulate them.

Now for Some Road Work.—*What to Do First.*—Having practiced with the pedals and levers until you are perfectly familiar with them you are ready for your *premier* as a driver.

Before you start be sure to (1) *fill the radiator* with clean water; (2) fill the *gasoline tank* with a good grade of gasoline; (3) *put lubricating oil in the engine;* (4) turn all the *grease cups once around,* and, finally, (5) turn on the *gasoline*—every car has a pet cock for this purpose. If the gasoline system is of the *pressure feed* type be sure there is enough pressure in the tank.

Just Before You Start.—The next few things to do are (1) *to put in the ignition switch;* (2) *throw the gear shifting lever* to the *neutral position* as shown in Fig. 5—that is, so that none of the transmission gears mesh; (3) set up *the throttle lever*—this is usually the longest and the upper lever on the brass *quadrant,* or *semi-circle,* fixed to the steering post—to about 45 degrees. The distance varies according to the make of the car. The demonstrator will show you the exact point to set it from the base of the quadrant as shown in Fig. 6; (4) advance the *spark lever*—this is usually the shortest and lower lever on the quadrant—that is,

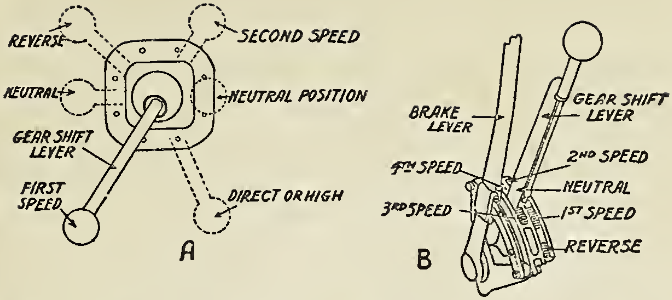


Fig. 5.—A. Top view of a ball gear shift lever. B. A gear shift lever working in a speed selector, or gate.

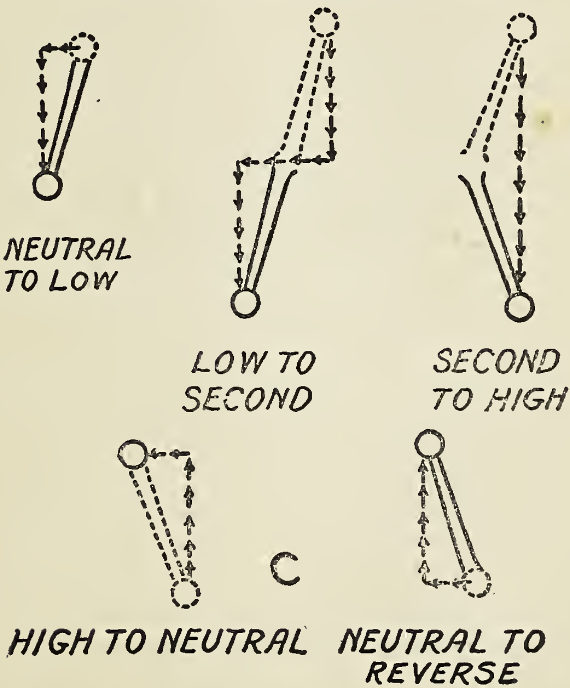


Fig. 5.—C. Gear shifting table for a ball lever.

move it about 90 degrees[1] from the base of the quadrant, or semi-circle, and (5) *flood the carburetor,* either by pulling out on the *priming rod,* which in the cheaper cars projects through the radiator, or by press-

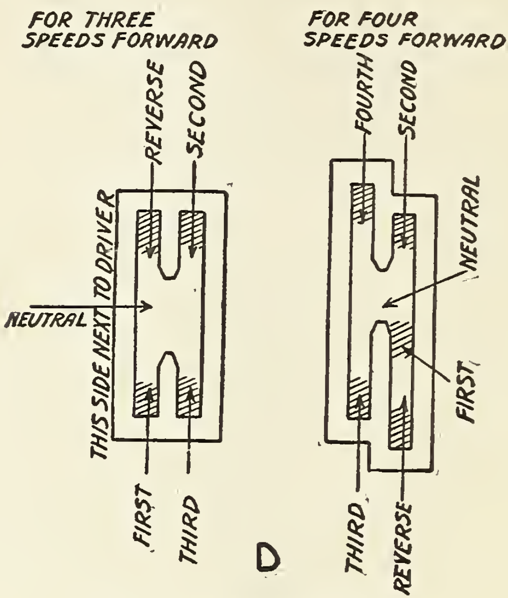


Fig. 5.—D. Speed selector gates.

ing the *priming button* on the dash in the better car; (6) close the switch.

Next Start the Engine.—Now start the engine either by *cranking it by hand* or by using the *self-starter,* according to the kind of car you own.

[1] Here again the distance varies according to the make of the car.

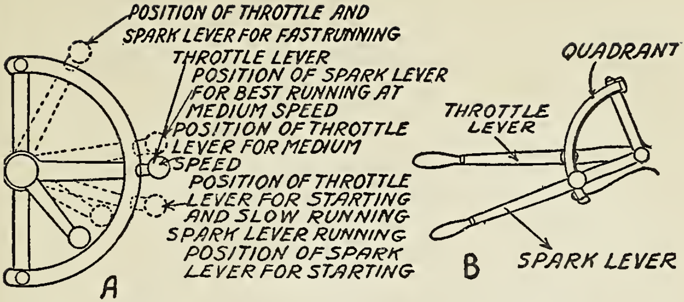


FIG. 6.—A. Relative position of throttle and spark lever on semicircle. B. Throttle and spark levers on quadrant.

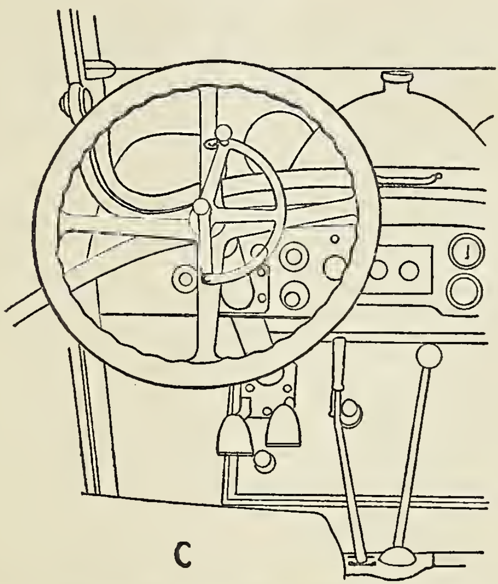


FIG. 6.—C. The throttle and spark levers on the steering post.

(1) Where a self-starter is used all you need to do is to push down on the *starting switch* with your foot and it will do the rest.

(2) If your car is one that you have to crank by hand, grasp the handle of the crank with your right hand and keep your thumb and fingers on the same side and in the same way as shown at A in Fig. 7, and stand

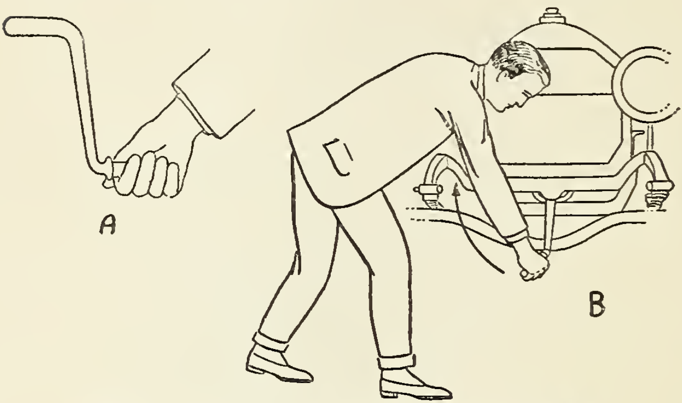


Fig. 7.—A and B. The proper way to crank a car.

with your left side toward the car as shown at B; turn the handle *clockwise* and push in on it until it *meshes,* that is, catches in the crank shaft of the engine, and then give it a quick half-turn up from its lowest to its highest position, when the engine ought to start.

Should the repeated half-turns of the crank fail to start the engine give the handle a complete turn but in so doing be very careful on the down stroke because the handle may be kicked the other way by the back fire of the engine and you may get your arm hurt.

If a *magneto* is used instead of a *battery ignition system* you can turn the crank around several times without stopping, or *spin it* as it is called, without danger, provided the spark lever is not advanced too far.

When the Engine Is Running.—After the engine starts (1) move the *throttle lever down* a little—see A in Fig. 6—when the engine will run slowly; (2) move up the spark lever to give the engine more power and (3) if there is a lever or a button on the dash for the carburetor adjust it until the engine runs smoothly.

You Are Ready to Go.—When the engine is running smoothly then (1) release the *hand* or *emergency brake* and at the same time hold the car with the *foot* or *service brake* as shown in Fig. 8, and *don't forget to do it* either.

(2) Grasp the *steering wheel* on each side; (3) *press out the clutch* by pushing in on the clutch pedal with your foot—this disconnects the engine from the driving shaft; (4) throw the gear shift lever from *neutral* to the *first speed* position as shown in Fig. 5, and (5) release the service brake with your right foot.

(6) Now with the same foot press the *accelerator pedal,* see Fig. 8 again, which is connected with the throttle lever, until the engine picks up in speed; (7) let your foot up *gradually* on the *clutch pedal* when the clutch will begin to take hold and you will find your car slowly running along the road.

How to Shift the Gears.—When the car has gained a little headway and you want to go faster (1) press the accelerator pedal to give the engine more

gasoline, and hence more momentum; then (2) push out the clutch; (3) throw the gear shift lever over to second place, or *speed* as it is called, as shown in Fig. 5, and this will carry you along faster but with less power.

Always be sure to press out the clutch before you shift the gears or you will strip off the teeth. When you shift the gears to the next higher speed don't do

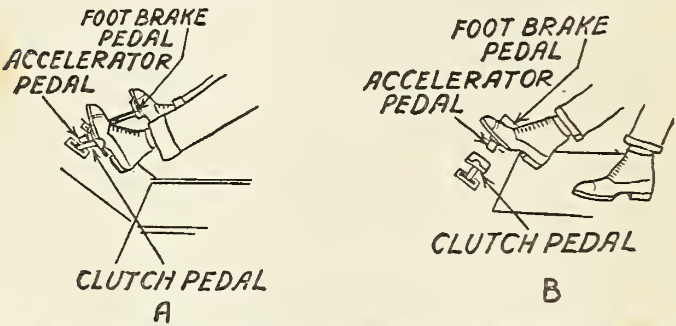


Fig. 8.—A. Always press out the clutch before shifting the gear lever. B. Press the accelerator pedal with your right foot.

it too quickly; neither do you want to wait until the car has slowed down after you have pressed out the clutch.

After a very little running you will know intuitively when the speed is reached where you ought to change to the next higher gear. The load you carry and the kind of a road you are on taken together determine the speed gears you should use and the time to change them.

On Direct or High Gear.—When you have changed from second to direct, or high speed gear you can run nearly as slowly as you did on low gear—that

is, if you want to; or you can run as fast or a little faster than the law allows; in fact, you can get any speed you want by simply pressing on the accelerator pedal more or less, which feeds the fuel mixture into the engine.

In learning, drive your car quite slowly when it is on

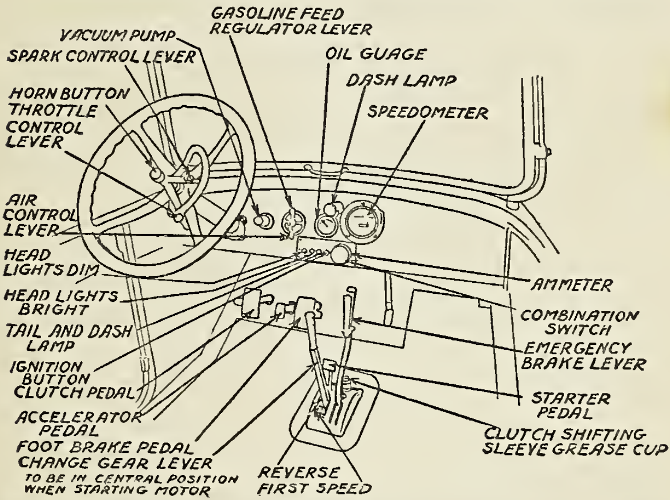


Fig. 9.—The fittings of the driver's compartment of a Hudson Super-Six.

high gear and you can do this by *throttling down* the engine with the throttle lever to the speed you want; but be careful not to throttle it down to the point where the engine labors or stalls altogether.

To Slow Down and Stop the Car.—(1) When you are running along and want to *slow down* lift your foot from the accelerator pedal and press down on the brake pedal, when not only the brake but the engine

will retard the car. When the speed of the car falls to less than 10 miles per hour press out the clutch.

(2) To stop the car press on the clutch pedal and the brake pedal at the same time, and (3) if you are in danger of running into something pull the hand emergency brake back also at the same time with all your might. But this procedure is mighty hard on the tires, so avoid it if possible. See Fig. 9 and also A Fig. 75.

(4) When you stop the car always see to it that the gear shift lever is set in the *neutral* position. (See Fig. 5.)

How to Stop the Engine.—All you have to do to stop the engine is to (1) pull the throttle lever clear down to the base of the quadrant, and (2) turn the ignition switch key off.

A better way to stop the engine is to (1) pull the throttle lever about half way down—in order to fill the cylinders with a rich charge—and then (2) turn off the ignition switch; this will enable you to re-start your engine very easily *on compression* as it is called.

Learning to Take a Curve.—Knowing now how to start, run and stop a car your next move is to learn to *take a curve,* that is, how to turn a corner.

Since you turn the steering wheel in the direction you want to go[1] and as you turn it in proportion to the curve you want to take, it comes just as easy and natural as pulling on the right or left line of a *dinosaurus* and saying *gee* or *haw,* and it's not nearly as nerve racking either because you don't have to swear at the

[1] This means that the top of the wheel is turned in the direction you want to go.

beastie at the same time. Practice turning left-hand corners as well as right-hand ones.

Always slow down when you turn a corner for it is not only dangerous to take a curve at high speed but it is very hard on the tires as well.

About Backing Your Car.—Practically all cars that are built at the present time have only one speed on which they can be reversed.

To back the car (1) *push out the clutch;* (2) *throw the gear shift lever* over to the *reverse position* as shown in Fig. 5; (3) accelerate the engine a little by pushing down on the accelerator pedal and (4) let the clutch in gradually.

If you want to back straight away of course you must keep the front wheels straight, that is, in *alignment* with the rear wheels. To back the car either to the right or left turn the steering wheel exactly as you would to turn it to the right or left when going ahead, as the diagrams A and B in Fig. 10 show.

To turn your car around in a narrow street in order to reverse your direction drive up close to the right-hand curb as shown at C, make a short turn and run up close to the opposite curb and at right angles to it; now throw the gear shift lever into the reverse position and then back the car until it is headed in the direction you want to go and far enough away from the curb to easily clear it when you go ahead again.

When Going Up a Hill.—A gasoline engine is different from a steam engine in that it develops power only when it is running at a fairly high speed. Again the faster a car runs the more momentum it gathers, that

is, the farther it will run after the power is shut off.

Bearing these two facts in mind when you are about to negotiate a hill, however long, or steep, or both, it

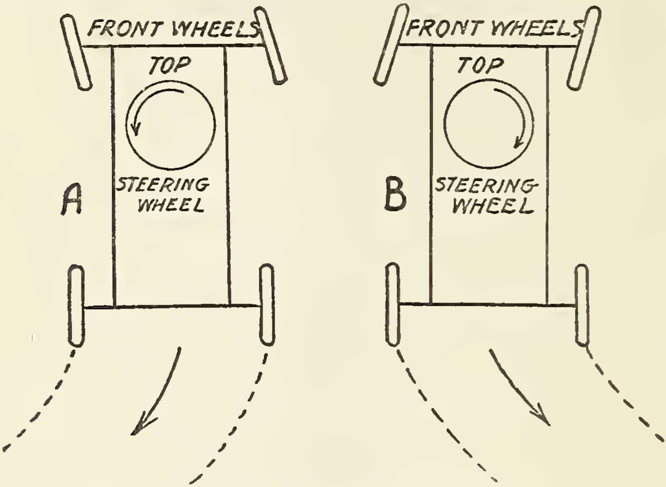
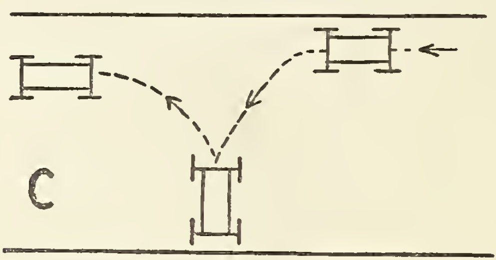


FIG. 10.—A and B. How a car is backed.



C. Reversing direction of car in a narrow street.

may be, give your car a good running start. When the force of the momentum has spent itself, and the moment the engine begins to lose power, shift the gear lever

over to second speed. If the engine begins to labor when on second, shift the gears to the first speed notch.

After a long climb has been made if you bring the car to a stop throttle down the engine and let it run for five minutes so that it will cool off gradually; by so doing you will find it will work much better when it is started again.

When Going Down a Hill.—If you are not already running on high gear when starting down a hill throw the gear shift lever over to high, press out the clutch and let the car coast.

Keep the speed of the car under control with the foot brake and use the emergency brake only if necessary. On reaching the bottom of the hill when the speed of both the engine and the car is the same let the clutch in again.

Should the hill be a very steep one the engine can be used as a brake; to do this throw the gear shift lever into *second* just before you start down, switch off the ignition system, and let the clutch in very gradually; of course you use the brakes as before.

When on Bad Roads.—Suppose in driving along you come to a bit of road that is bad, don't try to run on your high gear but shift the gear lever over to second right away.

Never hit a hollow or a bump end on but go over the rut or ridge very gently at a slant for then the springs won't get the full shock all together but one at a time.

Should the road be muddy, or sandy, the engine may commence to *pound,* or to run badly; the remedy for

this is to retard the spark by setting down the spark lever and you will quickly find a point where the engine works smoothly.

What to Do When the Car Skids.— Driving over wet streets without *chains* on the rear tires is a dangerous procedure, but sometimes it can't be helped.

To keep the car from skidding take all curves very slowly and use your brakes very gently. Should the car begin to skid the rear wheels will slip sidewise and this is your cue to instantly turn the front wheels in the direction the car is skidding; if you do this quickly enough the car will skid but little farther.

Sometimes when the brakes are put on too hard the car will take a notion to skid and also when the power is too suddenly applied; in either case the thing to do is to release the brakes and the car will right itself again.

The Rules of the Road.—When you meet another vehicle on the road pass it on the *right* side as shown at A in Fig. 11. Should you overtake a vehicle and want to pass it, toot your horn and drive ahead of it on the left-hand side and as rapidly as possible, but without cutting in short ahead of it, as shown at B.

When coming to a cross-road or a street where you cannot get a clear view of the road in both directions, slow down your car to a speed where you can easily stop it should there be another vehicle coming from either direction.

When you want to turn your car into another street, or road, to the *right* keep your car as near the right-hand curb as possible as shown at C in Fig. 11. When

FIG. 11.—The right ways to pass a vehicle.

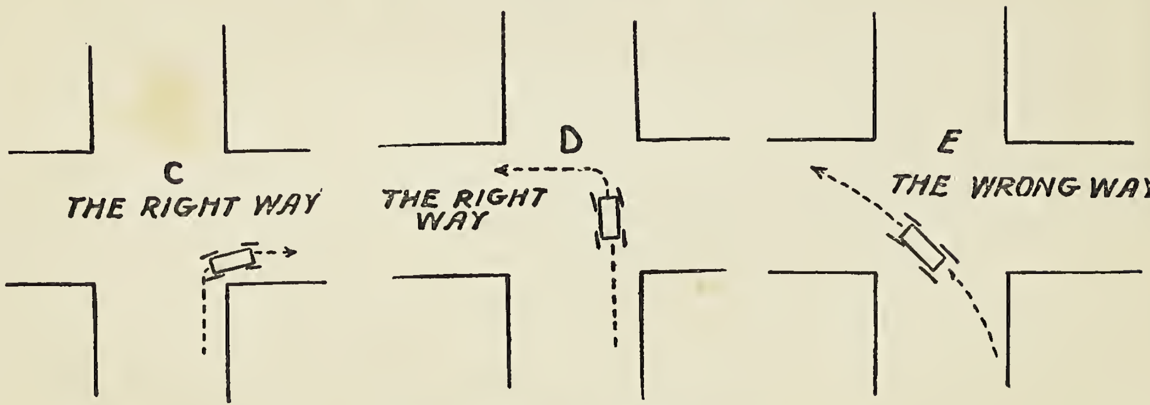


FIG. 11.—Turning into another street.

you turn into another street to the *left* you should go around the center of the intersecting streets as shown at D. The wrong way is shown at E.

When you intend to turn to the right hold out your hand on the right side of the car and when you intend to turn to the left hold out your hand on the left side of the car so that those behind you will know what you are going to do. Also signal in the same way when you are slowing down or are about to stop.

When nearing a railroad crossing throw the gear shift lever over into second speed and drive up cautiously to see if you are safe in making it and if you conclude you are, accelerate the engine so that there will be no danger of stalling it.

When approaching frightened horses bring your car to a stop if necessary and sometimes you may have to stop the motor. Then if anything happens it won't be your fault.

To Equalize the Traction.—Always use tires of the same size and tires having the same tread on the rear wheels, and if you use chains use them in pairs.

A difference in the diameters of the rear tires makes the tractive effort of the wheels vary and this makes the *differential* work all the time the car is running, thus causing needless loss of power and a useless wearing of the parts.

CHAPTER III

THE VARIOUS PARTS OF A CAR

Just as all gasoline motor cars of the passenger type have the same general design so also all of them are built on the same general lines and operate on the same general principles.

This being true it is obvious that if you understand the construction and operation of any one car you will have a pretty good working knowledge of all the others and so the first thing you ought to do before you buy a car is to know something about one.

The Main Parts of a Car.—A motor car of whatever kind consists of five chief parts and these are:

1. The frame.
2. The running gear, or *chassis.*
3. The power plant.
4. The transmission mechanism, and
5. The body.

The Running Gear, or Chassis.—The word chassis[1] (pronounced *cha'ze*) includes (1) the *front axle;* (2) the *steering gear,* which turns the front wheels;

[1] This is a good old French military word and means the carriage on which a gun is mounted so that it can be run in and out of a battery.

(3) the *rear axle;* (4) the *wheels* and (5) the *brakes,* all of which are mounted on (6) the *frame.*

What They Are Made of and How.—*The Frame.*—This is the part on and around which all the other parts are built. It is made of a pair of *channel section beams,* or *side members* as they are called, and these are strongly braced by *cross members* and *gusset plates* to prevent it from weaving and twisting. The

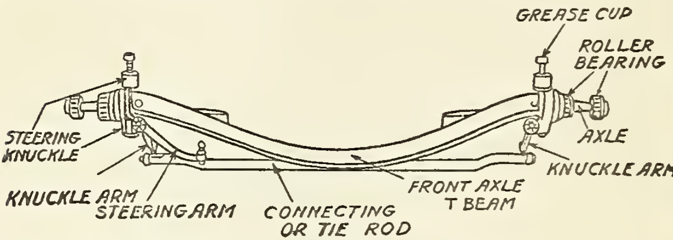


FIG. 12.—The front axle and steering knuckle assembly.

best frames are made of *chrome nickel heat-treated steel.*

The Front Axle.—This is usually made of an I beam section of *vanadium steel*—which will twist but will not break—and to the ends of which *ball* or *roller bearing* hubs are fitted; the hubs are swung on the axle by means of pivot jaws and the *steering knuckles,* as the swinging parts are called, are connected together with a *connecting rod,* all of which is shown in Fig. 12.

The Steering Gear.—As shown at A in Fig. 13 the steering gear consists of the *steering wheel,* which operates either a *worm gear* as shown at B, or a *screw and nut* movement as at C by means of a *shaft* which passes through the *steering post;* this motion is transmitted

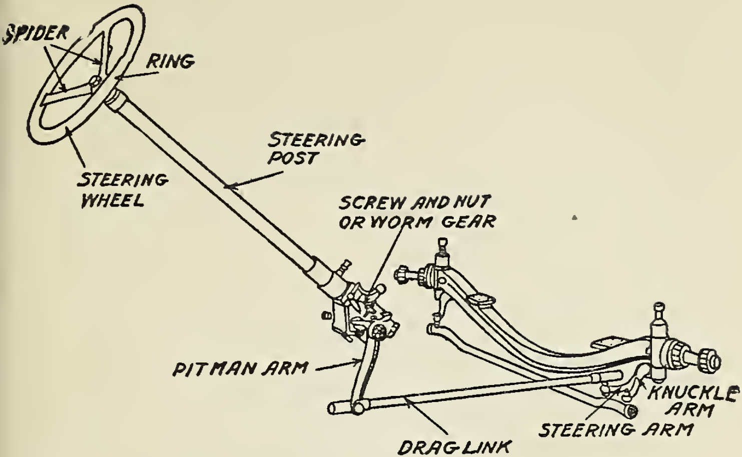


Fig. 13.—A. The steering wheel linked to the steering assembly.

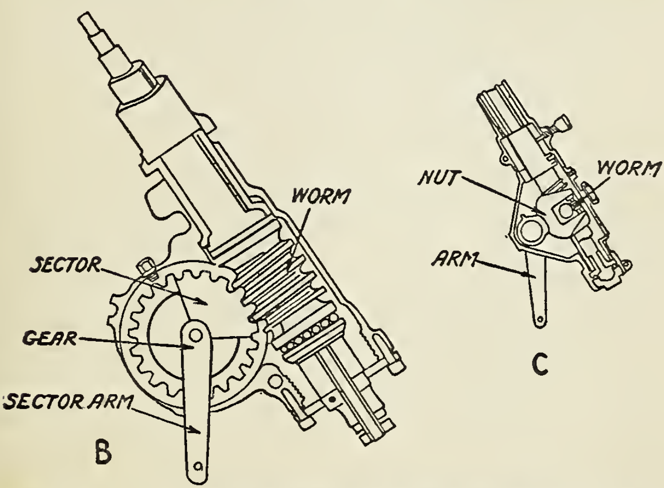


Fig. 13.—B. Worm gear exposed, showing bearings and thrust.
C. Screw and nut gear.

to a *pitman arm* by the gear or nut; in turn the pitman arm is pivoted to one end of the connecting rod while the other end is pivoted to the drag link which moves the steering knuckles. The way in which the front axle and the steering gear are fixed to the frame is shown in Fig. 14.

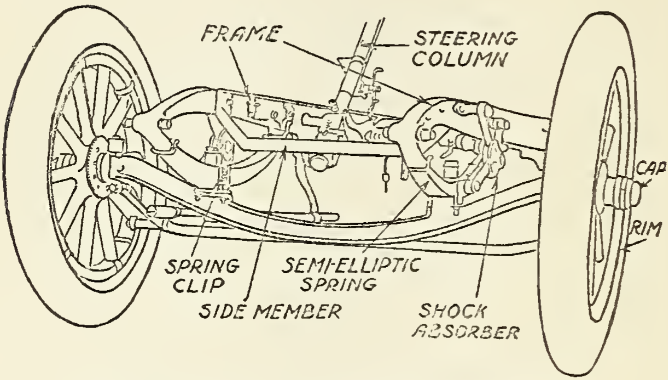


Fig. 14.—Front axle and steering gear assembly.

The Rear Axle.—This is made up of a lot of parts, as shown in Fig. 15; first there are two steel *axle shafts,* one for each of the rear wheels, and these are usually roller bearing; these shafts are enclosed in a tube called a *housing,* and the inside ends of the latter are welded to the *differential gear case* while the outside ends are joined to the *brake flange plates.*

Rear axles are of (1) the *semi-floating type* or (2) the *full floating type.* These terms simply mean the way or method by which the weight of the rear end of the car is held up by the axle.

With the semi-floating axle the weight is carried

first by the axle shafts and then it is transmitted to the housing. In the full floating type the weight is carried entirely by the housing. Both of these types are good and both are used in the best makes of cars.

The Suspension.—By which is meant the manner and the means employed for securing the frame of the car to the running gear. This is done by using springs of various kinds and the best suspension is the one that

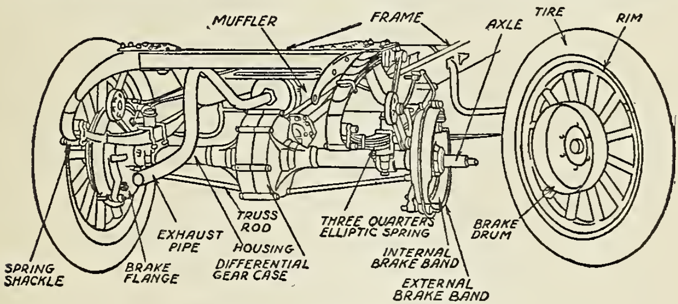


FIG. 15.—Rear axle assembly.

absorbs the shocks of uneven roads to the greatest extent for this not only makes easier riding but it saves the machinery as well.

Five types of springs are used for motor car suspension and these are (1) *half elliptic;* (2) *three-quarter elliptic;* (3) *full elliptic;* (4) *platform* and (5) *cantilever,* all of which are shown in Fig. 16.

The *front springs* are generally of the half or semi-elliptic type; these springs are fixed to the axle with *axle clips* and to the frame with bolts—as shown in Fig. 14; it will also be observed that the housing of the steering gear is attached to the frame.

Over half of the *rear springs* used on cars are of the three-quarter elliptic type, with a sprinkling of full elliptic, a few half-elliptic and a very small percentage of the platform and cantilever types. Fig. 15 shows how the frame is mounted on the rear axle by means of three-quarter elliptic springs, and Fig. 16 shows how a cantilever spring is mounted.

The Service and Emergency Brakes.—Fundamentally a brake is a friction device where a fixed surface rubs against a moving surface with the result that the moving surface is brought to a stop. On a railroad car a *brake shoe* presses against the surface of the moving wheel, while in a motor car a *brake band,* usually lined with *asbestos,* presses against a *brake drum* which is fixed to the rear wheel.

There are two kinds of brakes on every car and these are (1) the foot or *service brake,* which is operated by a foot pedal, and (2) the hand or *emergency brake* which is controlled by a hand lever on the side of the car.

These brakes work inside and outside of a brake drum bolted to the rear wheel; the foot or service brake consists of a *steel band* lined with a strip of woven asbestos and when you push the brake pedal it draws the band together and tightens it on the brake drum as shown at A in Fig. 17; hence a brake of this kind is said to be of the *contracting type.*

The hand or emergency brake consists of a *steel band* covered with either asbestos or with a special kind of bronze, and this one works *inside* the brake drum so that when you pull the hand lever back the brake band

is spread apart and rubs against the drum as shown at B; for this reason it is called an *expanding* brake. The mechanism of the service or contracting, and the emergency or expanding brakes is shown in detail at C in

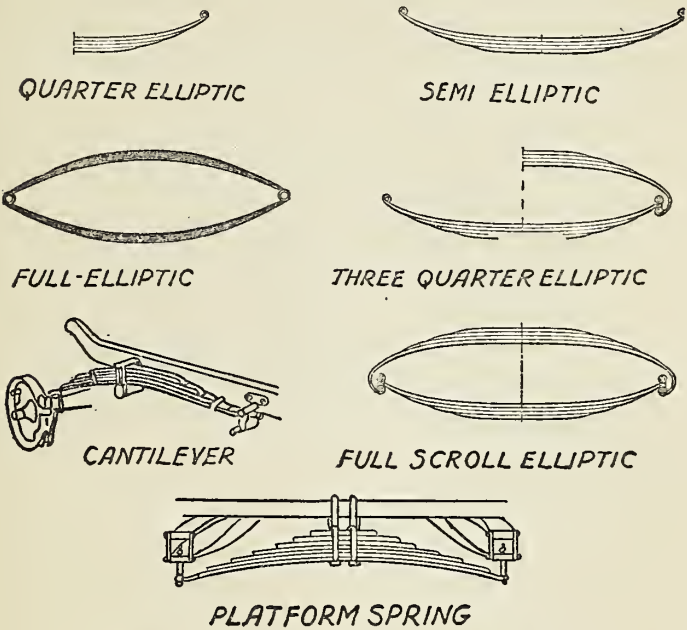


Fig. 16.—Kinds of motor car springs.

Fig. 17, while that of the assembled brakes on the rear axle is shown in Fig. 15.

The Wheels.—Three kinds of wheels are used on motor cars and these are (1) *wood wheels;* (2) *wire wheels* and (3) *hollow* steel spokes which resemble wood. When wood wheels or hollow steel spokes are

used the weight of the car rests on the lower spokes, while with wire wheels the spokes above the hub support the weight of the car.

Here are the claims of the makers of both wood and wire wheels. *Wood wheels* are cheaper, stronger and will stand more strain and rough usage; they are easier to keep clean and can be washed in half the time, and

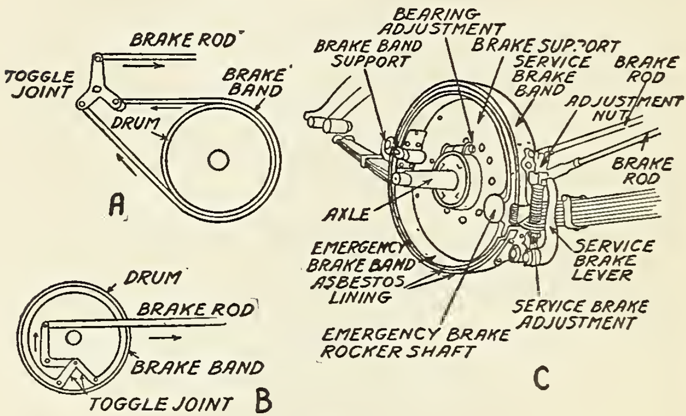


FIG. 17.—A. Sketch of external contracting or service brake. B. Sketch of internal expanding or emergency brake. C. The parts of the brake assembled.

lastly they are neater in appearance and will not rust. *Wire wheels* are lighter and more elastic; they save tires and gasoline; they possess great resisting strength and will stand severe shocks, and finally, they add to the attractiveness of a car.

Kinds of Tires and Rims.—A rubber tire for a motor car is formed of two parts and these are (1) the *inner* tube and (2) the *casing.*

The Inner Tubes.—The inner tube is simply a thin rubber tube with the ends joined together and fitted with a *valve,* as shown at A and B in Fig. 18; this is placed inside of the casing and when the latter is put on the rim of the wheel the valve stem sticks through a hole in the rim and felloe. It is then pumped up with

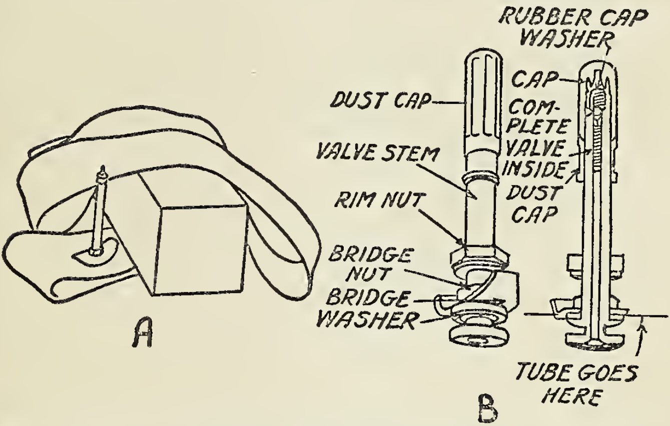


FIG. 18.—Kinds of tires and rims. A. An inner tube with valve. B. The valve of an inner tube.

air and this keeps the casing hard and yet makes it elastic.

The Casings.—There are two types of casings used and these are (1) the *clincher* as shown at C and (2) the *straight bead* as shown at D. The *bead* on a plain clincher casing is made of soft rubber while the bead on a straight bead casing is made stiffer and is often reinforced with wire.

The Rims.—There are three types of rims made for motor car wheels and these are (1) the *plain clincher*

rim as shown at E, (2) the *quick detachable rim* as shown at F, and (3) the *demountable rim* as shown at G.

The Clincher Rim.—For a plain clincher rim a clincher bead casing only can be used and you will see from the clincher casing shown at C that the beads

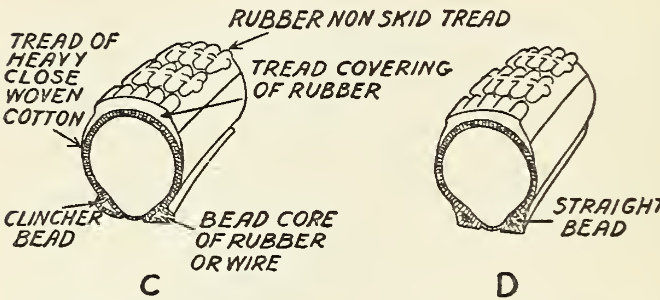


FIG. 18.—C. A clincher casing. D. A straight bead casing.

slip under the curved sides of the rim shown at E. This type of rim is to be found only on cars of the vintage of 1910 or before, and a few present cars of cheaper make. To take off a clincher tire the air must be let out of the inner tube and the valve stem pushed up into the casing as far as it will go. The bead can then be forced in from the curved side with a *tire iron* and when this has been done all around the tire can be pulled off.

The Quick Detachable Rim.—A cross-section of a quick detachable rim is shown at F. The way it is constructed makes it easy to take off and put on a tire as against the clincher type. It consists of two clincher rings, or they can be straight bead rings, and a third

and outside ring which can only be taken off when the tire is deflated.

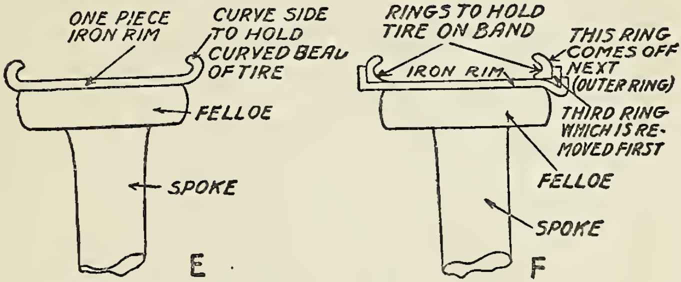


Fig. 18.—E. A clincher rim. F. A quick detachable rim.

To take a tire off the inner tube must be deflated first and the valve stem pushed up into the casing as

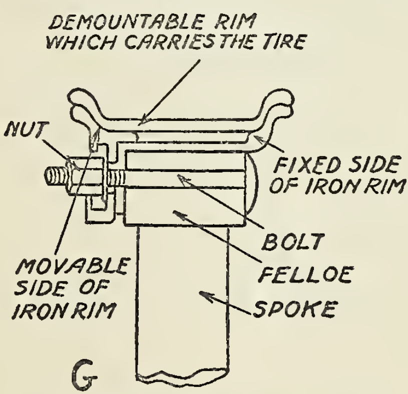


Fig. 18.—G. The demountable rim.

far as it will go; this done, the third and outside ring, which is cut at one place, can then be easily taken off.

After the third ring is off the clincher, or straight bead ring can be slipped off and then the tire.

The Demountable Rim.—A later device to help the impatient motorist on his swift way is the demountable rim. In this type the tire is put on a separate rim which may be either of the clincher or straight bead type; this demountable rim can be taken completely off of the rim fixed to the felloe when a new rim with a fresh tire can be put on in its place. In this way a tire can be changed in a few minutes and the punctured tube or blown-out casing can be repaired when you get home.

The demountable rim is held in place by a removable rim band bolted to the felloe of the wheel as shown at G; when the nuts are taken off of the rim band the latter can be slipped off and then the demountable rim which carries the tire.

The Removable Wheel.—The last word in getting over tire troubles is to remove the whole wheel with the tire on it from the hub and replace it with a new wheel and tire. This can be done with wire wheels only.

About the Power Plant.—The *power plant* of a motor car means the engine and all the auxiliary parts that have to do with the initial development of the power.

Engines for motor cars are built with 4, 5, 6, 8 and 12 cylinders, and develop from 20 horse-power which is used in the cheapest cars to upwards of 120 horse-power in the larger touring cars.

The engine is usually a self-contained unit, that is,

all its parts are built in or on to it and the whole plant is then bolted rigidly to the side and cross members of the frame. The design, construction and operation of engines will be taken up in the next chapter.

The Transmission Mechanism.—Between the crank shaft of the engine and the axle shafts of the rear-axle, which set at right angles to the former, there are several mechanical devices interposed, the purposes of which will be seen presently, and these when taken together are called the *transmission.*

The transmission includes the following devices (1) the *clutch;* (2) the *transmission gears* and their control; (3) one and sometimes more *universal joints;* (4) the *propeller shaft,* and (5) the *differential gears.*

The Clutch.—The purpose of a *clutch* is to enable you to connect and disconnect the engine from the propeller shaft, as the main driving shaft is called, at will. The reason a clutch is needed is because a gasoline engine can only develop power when it is running at a fairly high speed, as I think I mentioned before; hence when starting your car the engine must be gently and gradually connected with the drive or the engine will *stall* because it is overtaxed.

There are two general types of clutches and these are (1) the *friction clutch* and (2) the *magnetic clutch.* Friction clutches are used on all cars except those of one make and this is the Owen, which uses the magnetic clutch.

Friction Clutches.—So called because a surface fixed to the crank shaft of the engine and another surface fixed to the driving shaft of the car will, when pressed

together hard enough, cause the first one to turn the second due to the friction between them.

There are two types of friction clutches, namely, (1) the *cone clutch* and (2) the *disk clutch.*

The *cone clutch* is the most popular and is shown at A in Fig. 19. It is formed of a conical recessed member fixed to the crank shaft of the engine—the flywheel

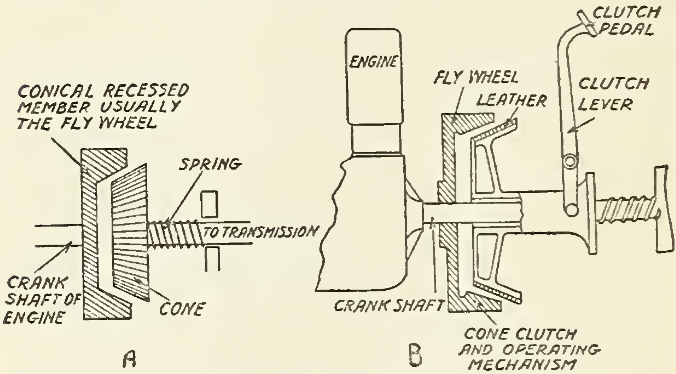


FIG. 19.—A. How a cone clutch works. B. Cone clutch and operating gear of an ordinary car.

is generally used for this part of the clutch—and a cone which is secured to the drive shaft; the latter is usually made of aluminum or pressed steel and faced with leather.

Of course when the cone is pressed into the recessed flywheel the friction between them will make the cone revolve. By letting the cone into the recessed member very gently the former will revolve slowly at first and then faster and faster until both are turning at the same speed.

A stiff spiral spring forces the cone into contact and keeps it there unless it is compressed by pushing in on the clutch pedal when the cone is pushed out and so comes the saying "push out the clutch." A cone clutch of a car is shown at B.

Disk Friction Clutches.—Clutches of this type depend for their operation on the friction produced by a

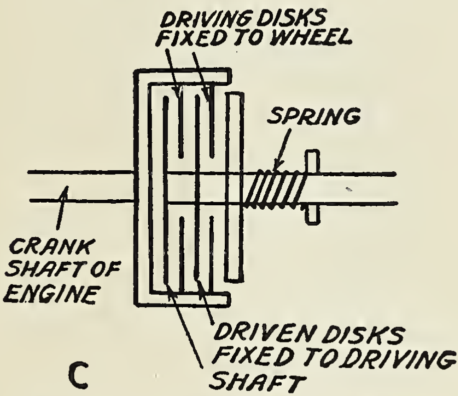


Fig. 19.—C. How a disk clutch works.

number of circular rings of sheet metal, called *driving disks,* which are fixed on studs and connected with the crank shaft of the engine, pressing against a like number of circular rings of sheet metal called the *driven disks,* which are mounted on the drive shaft, and so that they interleave as shown at C in Fig. 19.

A spiral spring keeps the disks on the drive shaft in close contact with the disks on the studs which are keyed to the flywheel of the engine except when pressed out by the clutch pedal.

Two kinds of disk friction clutches are used and these are (1) the *dry plate disk clutch* and (2) the *oil immersed disk clutch.* In the former the disks, which are keyed to the inside of the flywheel, are covered with woven asbestos cloth and these work against the soft steel disks which are keyed to the drive shaft. These

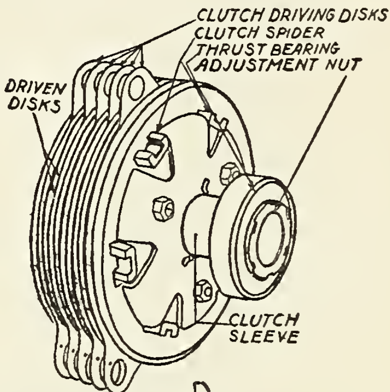


FIG. 19.—D. Disk clutch of a Chalmers Car.

plates *run dry,* that is, they are not immersed in oil. A Chalmers dry plate clutch is shown at D.

In the second kind the disks secured to the flywheel are made of steel plates as are also the driven disks, but the latter have a large number of holes in them into which corks are forced. The whole clutch is then immersed in oil.

The Magnetic Clutch.—In the *magnetic clutch* magnetism is used to form the connection between the crank shaft and the drive shaft instead of friction.

The principle of the magnetic clutch is clearly pic-

tured at E in Fig. 19. Suppose that a horseshoe magnet is mounted so that it can be revolved by a crank and a piece of soft iron is mounted so that it can be rotated between the poles of the magnet; now if you turn the crank the iron will turn with it for it is held to the poles of the magnet by magnetic attraction.

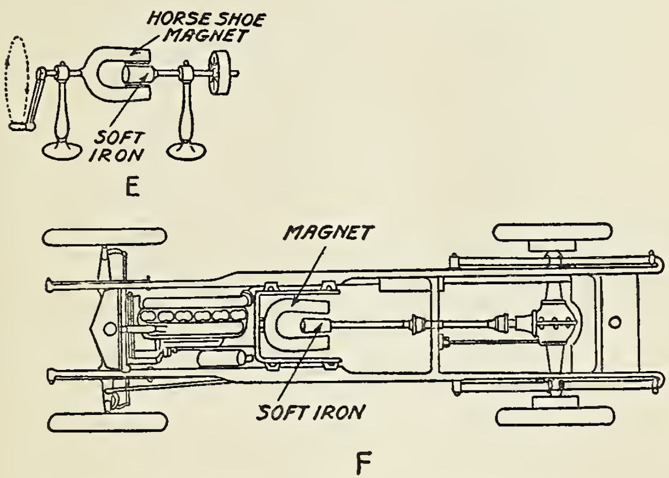


Fig. 19.—E. How the magnetic clutch works.
F. How the magnetic clutch works on the Owen Car.

Place this arrangement in a car as shown at F; revolve the magnet by means of the engine and connect the piece of iron to the propeller shaft when the *torque,* that is, the turning power of the engine, will be transmitted to the propeller shaft by the magnetic force.

Instead of a steel magnet use an *electro-magnet* so that you can make it as weak or as strong as you please.

Now when you want to change speeds you only need to change the strength of the magnet and if you weaken it there will be a slippage between it and the iron, and

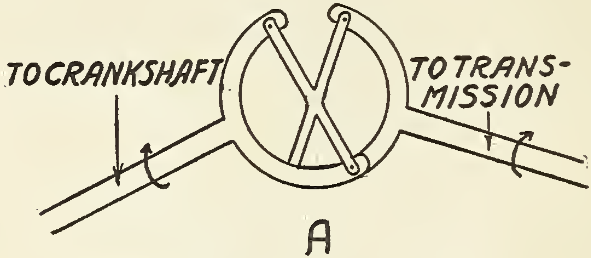


FIG. 20.—A. How a universal joint works.

in this way you can get any speed you want without friction clutches and without transmission gears.

The Universal Joint.—Since it is impossible for the propeller shaft, which is bobbing up and down all the

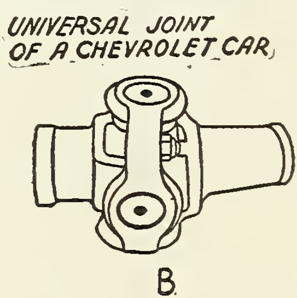


FIG. 20.—B. The universal joint of a Chevrolet Car.

time the car is running, to be directly connected and in alignment with the rigid crank shaft of the engine a *universal joint* is used to couple them together.

Now a universal joint is a coupling that permits both of the connected shafts to turn no matter what position they are in. In its simplest form it consists of a U-shaped end on each shaft and these are secured with pivots to the ends of an X as shown at A in Fig. 20.

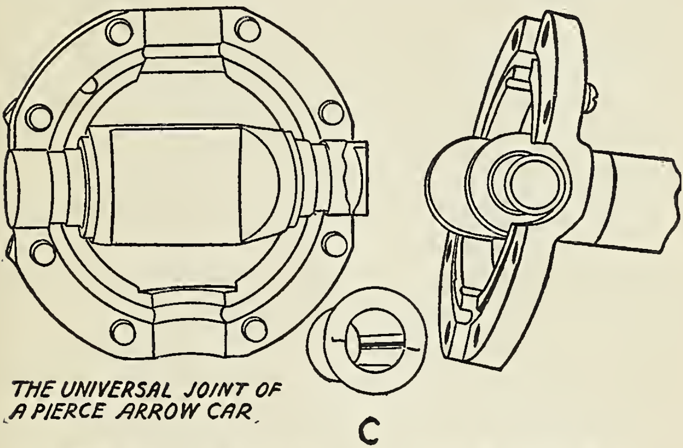


Fig. 20.—C. A universal joint of a Pierce-Arrow Car.

The universal joint used in the Chevrolet car is shown at B and the kind that is used in the Pierce-Arrow car is shown at C.

The Transmission.—Since a gasoline engine must run at a very high speed and a car runs anywhere from 0+ up to 50 miles—a little more when the constable isn't looking doesn't matter—these differences must be equalized and this is done through what is called the *transmission*.

The purpose of the transmission, then, is to reduce the speed developed by the engine before it is trans-

mitted to the propeller shaft as may be required, and hence it follows that the smaller fast moving force of the engine is changed into a slower but more powerful force before it is transmitted to the propeller shaft.

Transmissions are of two general types and these are (1) those using *change gears* and (2) those using *friction wheels.* Change gear transmissions can further be divided into two classes, namely (a) those with *sliding gears* and (b) those with *planetary gears.* Sliding gear transmissions have three or four forward speeds, while planetary gear transmissions are usually limited to two speeds ahead, and both kinds have one reverse speed.

Sliding Gear Transmission.—Now let's take a three speed forward and reverse transmission such as is used in nearly all medium-priced cars and find out just how it works. To begin with we'll consider the forward speed gears first, that is, those that propel the car ahead, and then we'll look into the reverse speed gears.

Suppose, by way of illustration, you fasten a small gear on the end of the crank shaft of the engine and a large gear to a *counter-shaft* so that the gears will mesh as shown at A in Fig. 21. It must be clear now that the crank shaft, or clutch shaft as it is called because it connects with the clutch and which in turn connects with the crank shaft of the engine, will make the counter-shaft revolve, though not so fast and in the opposite direction. Now set a third, or *main-shaft,* in line with the crank shaft and put a small gear on this one which you can slide on it and yet so that it will revolve with it; one way of doing this is to make the shaft square and the hole in the gear square.

Key another and second gear on the counter-shaft so that it will turn with it; if now the sliding gear on the main-shaft is shifted over so that it will mesh with the second gear on the counter-shaft as shown at B, of course the power will be transmitted from the engine to the counter-shaft and thence to the main-shaft, which

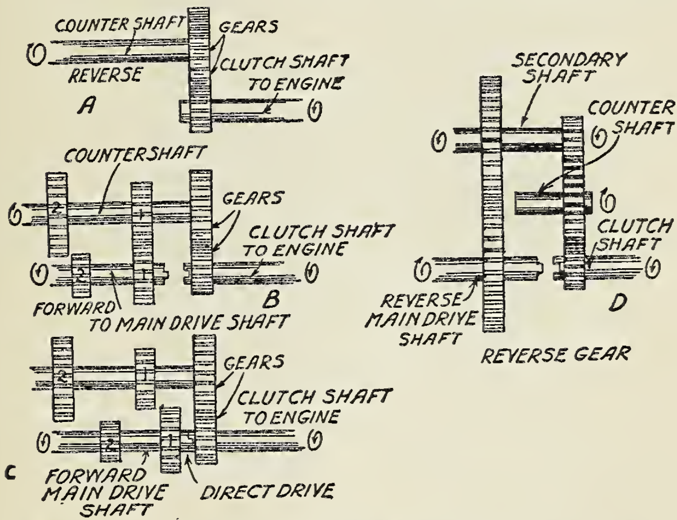


FIG. 21.—A, B, C and D. Diagrams showing how forward and reverse transmission gears work.

is direct connected to the propeller-shaft through the gears, and the speed at which the latter revolves will depend on the speed of the engine and on the relative sizes of the change gears. By using gears of different ratios three or four speeds may be had.

In looking at any picture of a transmission just bear in mind that there are two separate and distinct shafts

in the gear case for forward speeds, and you will have no trouble in understanding it.

When the car is running on second gear and you shift the gear lever over to *direct,* or high speed, the end of the main-shaft is forced into the end of the clutch shaft and locked there so that the engine is direct connected with the propeller shaft as shown at C; this

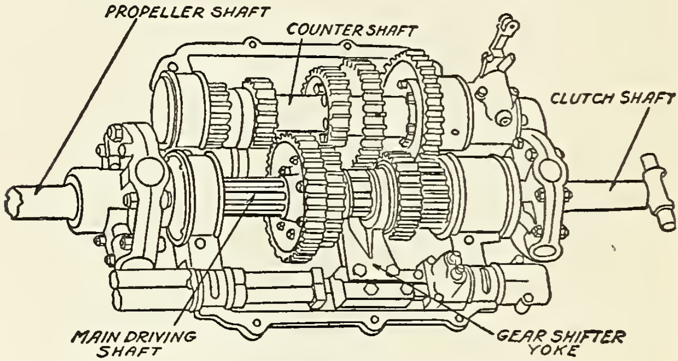


FIG. 21.—E. Four-speed forward transmission.

is the reason only two pairs of gears are needed for a three-speed transmission and three pairs of gears are needed for a four-speed transmission.

To reverse the direction of the propeller shaft a fourth shaft, called a *secondary-shaft,* but which is really only a pin, which has a gear that meshes with one on the counter-shaft and another gear that engages a gear on the main-shaft, is used. It is hard to show this secondary-shaft in a picture when the other two shafts are seen because it is directly under the counter-shaft, but the diagram shown at D will give you the idea of it.

The sliding gears are shifted along on the propeller shaft by means of a *shifter yoke* which fits into grooved disks as shown at E; the *shifter shaft* is secured to the yoke and the gear shift lever is fastened to the shaft.

The *transmission assembly,* as the shafts and gears are called, are enclosed in a *transmission case* made of

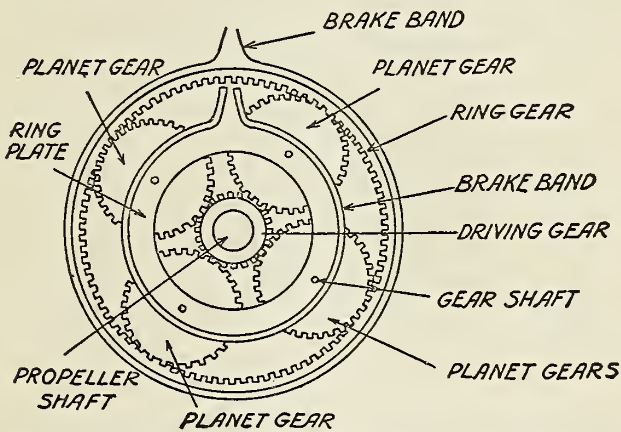


FIG. 22.—A. Diagram showing how a planetary transmission gear works.

cast aluminum and the case is then partly filled with *fiber grease* or some other gear compound.

Planetary Gear Transmission.—In this kind of transmission all of the gears are in mesh all the time. The scheme is shown at A in Fig. 22, in which the driving gear is fixed to the clutch-shaft and the four small *planet gears* turn on spindles fixed to the ring plate; these mesh with the driving gear and also with the large *internal ring gear.*

A brake band is fixed around the plate carrying the small gears so that the plate can be stopped from turning when only the small gears will revolve. A brake band is also fixed around the ring gear so that it can be stopped from turning. A change of speeds is had as follows:

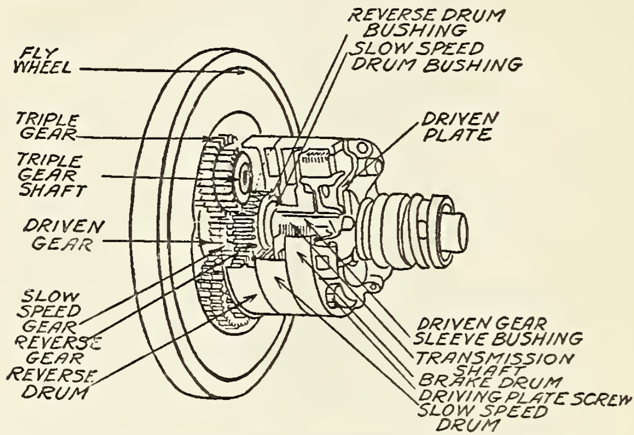


FIG. 22.—B. Planetary gear transmission used on the Ford Car.

When high speed is wanted the brake bands are loose and all of the gears revolve together; for low speed the brake band around the ring plate is tightened so that it cannot turn and this forces it to revolve in the same direction as the driving gear but at a much slower speed. To reverse, the brake band around the ring gear is tightened and then the ring gear revolves in the opposite direction to the driving gear, though much slower. The Ford, which is shown at B, and all other planetary transmissions, work on this principle.

Friction Wheel Transmission.—This type of

transmission consists of a large wheel, or disk, fixed to the end of the crank shaft and a smaller wheel secured to the propeller shaft; now when the small wheel presses against the large disk, as shown at A in Fig. 23, it is made to revolve by the rolling frictional contact between them.

By changing the position of the driven wheel on

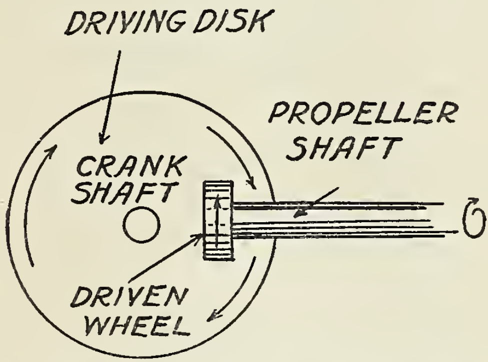


Fig. 23.—A. Diagram showing how a friction transmission works.

the surface of the driving disk a wide variation of speed can be had and by moving the position of the small wheel from one side to the other across the center of the large disk both forward and reverse speeds can be had. This transmission also serves the purpose of a clutch. It is used in the Metz and the Lambert cars as shown at B.

The Propeller Shaft.—This shaft couples the transmission gears with the differential through a universal joint. It should be made of vanadium steel, heat-

treated, as this alloy will not break under torsional stresses but will simply bend.

The Final Drive.—Last of all of the running gear is the *final drive,* that is, the means which transmits the power direct to the rear wheels. There are

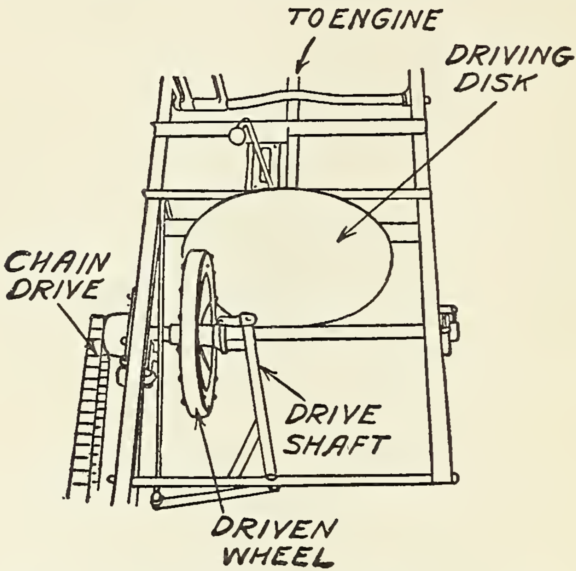


FIG. 23.—B. The friction transmission of a Metz Car.

two types of final drives and these are (1) the *center-shaft* and (2) the *side chain drive.*

With the exception of three or four of the cheaper cars which use the chain drive the center-shaft drive is used on all passenger cars.

The Differential.—The reason a *differential gear* is used is that when the rear axle of a car goes round a

curve the inside wheel moves faster than the outside wheel and the gears must not only drive the wheels

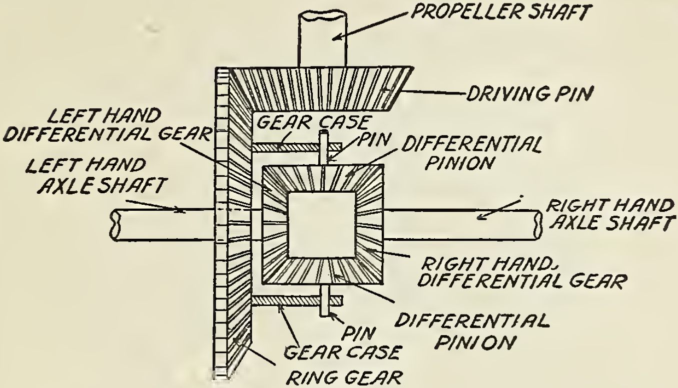


FIG. 24.—A. Diagram showing how the differential gears work.

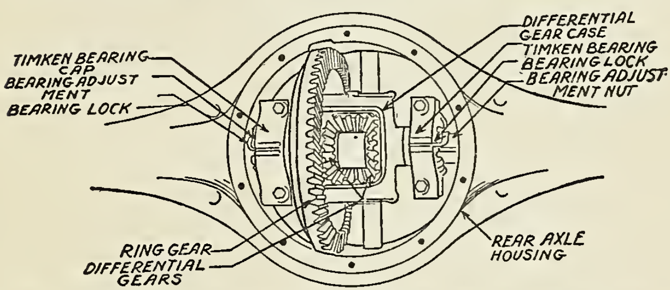


FIG. 24.—B. The differential gears in their housing on the rear axle of a Chalmers Car.

but at the same time allow them to run at different speeds.

The *differential* works like this: A *driving gear* is fixed to the end of the propeller shaft and this meshes

with and drives a *ring gear.* To the *ring gear* is fixed a *differential gear case* and this turns with it. There are four differential gears, and one of these is secured to one of the axle shafts and the other to the other axle shaft as shown at A in Fig. 24; the upper and lower

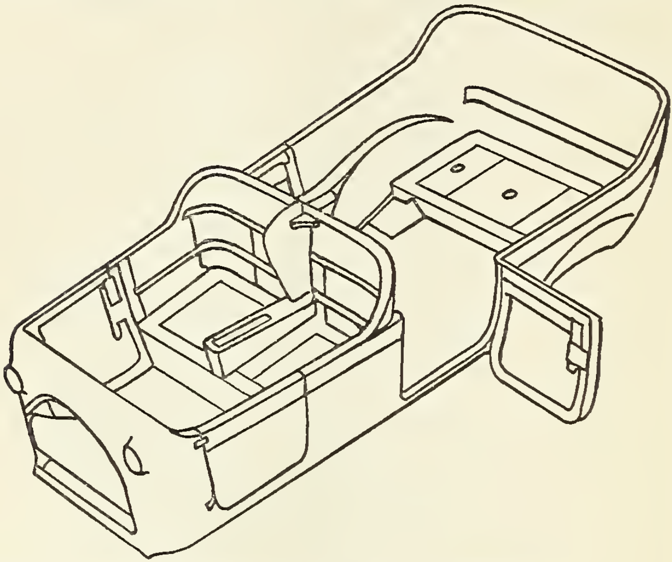


FIG. 25.—A car body built up of cast aluminum plates and backed up by wood.

differential gears are pivoted to the gear case and these mesh with the gears fixed to the axle shafts.

Now when one of the rear wheels runs faster than the other, the pivoted differential gears not only revolve on the pins in the gear case, but they turn at the same time around the gears on the axle shafts. In this way any difference in the speed of the rear wheels makes

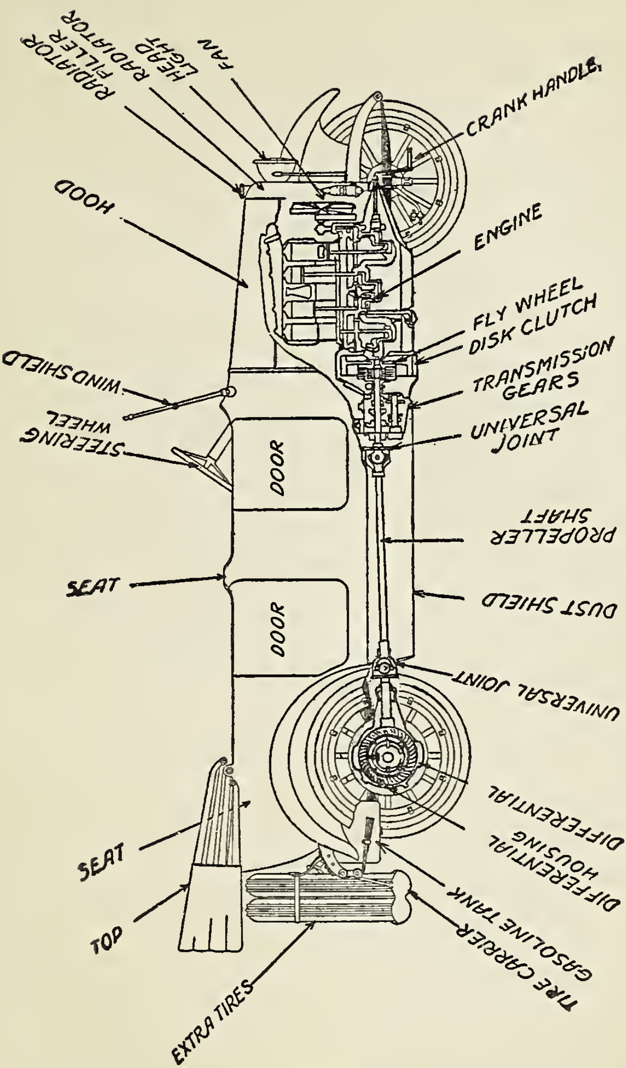


Fig. 26.—The parts when assembled make a car.

the differential gear on one axle shaft turn independently of the gear on the other axle shaft. The differential gears in the housing on the rear axle are shown at B.

The Chain Drive.—Occasionally the rear wheels are driven by chains on sprocket wheels like those on a bicycle. Where this is the case either a differential or a friction transmission must also be used.

The Car Body.—The bodies of cars are made of wood, iron and aluminum. Wood is very little used except where special bodies are made to order. Pressed sheet iron is largely used in the cheaper cars and pressed sheet aluminum in the better makes of medium grade cars, but some of the high grade cars are now using aluminum cast in sections which are riveted together; the shell thus formed is backed with wood and it is then given 15 or 20 coats of paint. A cast aluminum car body backed with wood is shown in Fig. 25, and an assembled car is shown in Fig. 26.

CHAPTER IV

HOW THE ENGINE WORKS

The power plants of nearly all motor cars are gasoline engines, though some of them have electric motors and a very few use steam engines.

The reason the gasoline engine is preferred is because the power is obtained directly inside the cylinders, whereas with the steam engine a high pressure boiler must be used and it is, in consequence, very hard to keep the joints from leaking.

Both the gasoline and the steam engine are *prime movers,* but electricity as it is produced today is a *secondary* power, that is, it must be generated by some other power first, and this limits its range of usefulness.

The Gasoline Engine.—All gasoline engines used in motor cars are built and work on the same fundamental principle, namely, that an explosive gas, called the *fuel mixture,* made by mixing air with gasoline, is drawn into the cylinder, where it is compressed by the piston and then *ignited* by an electric spark, when the resultant explosion forces the piston down and so produces power.

As there is only one explosion to every other down stroke of the piston in the cylinder, and no explosions on

the up strokes, there is only one power[1] stroke to every two revolutions of the crank shaft on a single cylinder engine; to obviate this bad feature four or more cylinders are used, and the pistons are so placed that there is a power stroke for every half turn of the crank shaft to which they are all connected. In this way the power developed is continuous, or practically so.

The Parts of a Gasoline Engine.—The easiest way to understand how a gasoline engine is made and how it works is to consider a one-cylinder engine first.

In this case the engine is built up of (1) a *cylinder* open at one end and closed at the other, in which (2) a *piston* moves to and fro, and this is connected to (3) a *connecting rod,* which in turn is connected to (4) a *crank shaft;* then there are (5) a pair of *timing gears,* one of which is fixed to the crank shaft and the other to (6) a *cam shaft,* which, when it revolves, opens and closes (7) a pair of *valves* at the right moment to let the explosive fuel mixture into the cylinder, and to let out the burnt gases.

To supply the cylinder with the proper mixture of gasoline and air (8) a *carburetor* is connected between the gasoline tank and the inlet valve in the cylinder head and finally, to explode the mixture (9) an *ignition system* is employed, that is, a high tension electric current is used to make a spark.

[1] On a single cylinder engine there is 1 power stroke to 2 revolutions of the crank shaft; 4-cylinder, a power stroke every ½ revolution of the crank shaft; 6-cylinder, a power stroke every 1/3 revolution of the crank shaft; 8-cylinder, a power stroke every ¼ revolution of the crank shaft; 12-cylinder, a power stroke every 1/6 revolution of the crank shaft.

In an engine made for motor car service where from four to twelve cylinders form the power plant, there are added (10) a *distributor* to send the electric current into each cylinder in turn and at the instant it is needed; (11) a *cooling system* to keep down the heat of the cylinders and (12) a *lubricating system* for oiling the moving parts of the engine, all of which will be described in separate chapters.

How the Engine Works.—The operation of a single cylinder engine can now be followed easily, and there is very little more to understand about a four-cylinder engine on up to a twelve-cylinder engine.

In Fig. 27, A, B, C and D represent the same cylinder with the piston in different positions at different time intervals during which the crank shaft has made two complete revolutions.

To begin with let's suppose that the inlet valve is open as shown at A, that the piston is moving down and that the fuel mixture is being drawn into the cylinder; the moment the piston reaches its lowest position the inlet valve is closed as shown at B and the piston then moves up and compresses the fuel mixture.

At the moment the piston reaches the top the spark is made and ignites the gas, when it explodes as shown at C, thus driving the piston down; hence this is called the *power stroke*. When the piston reaches the end of its power stroke the exhaust valve is opened, and when the piston again moves up it pushes the burnt gases out of the cylinder as shown at D.

From the above *cycle of operation,* as these four movements of the piston are called, you will readily see that

there is only one effective stroke and, consequently, only one effective half turn of the crank shaft in two revolutions on a single cylinder engine. Now to get an effective stroke for each half turn of the crank shaft so that the turning power, or *torque* as it is called, is continuous, four or more cylinders are used and the pistons

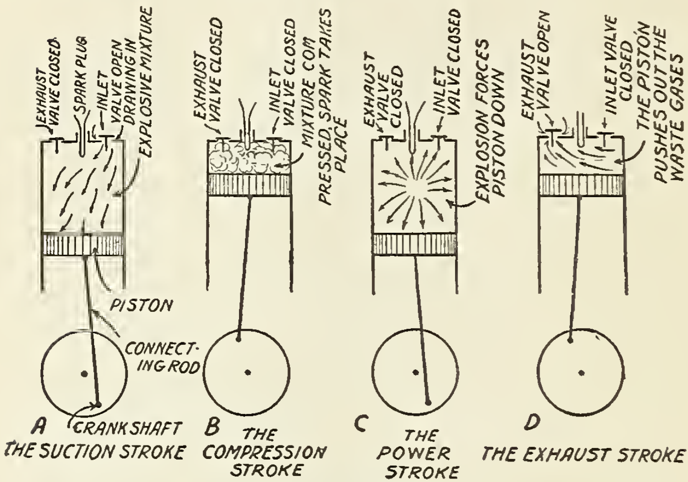


FIG. 27.—How a single cylinder engine works. A, B, C and D represent the same cylinder during two revolutions of the crank shaft.

on all of them are connected to one crank shaft as shown in the diagram, Fig. 28.

The Use of Multi-Cylinders.—In a four-cylinder engine there is a slight break in the effective power at the end of each power stroke of the pistons because each one must come to a full stop at the ends, or *dead centers,* of its stroke before it can reverse its direction.

To lap over these breaks and make the turning power continuous six cylinders are often used. An eight-cylinder engine gives four power strokes to each revo-

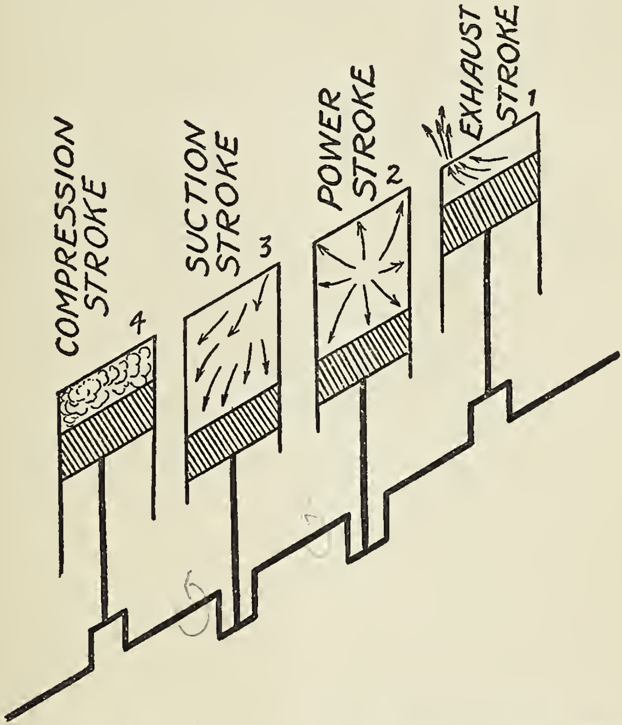


FIG. 28.—Diagram of a multi-cylinder engine showing how the pistons are connected to the crank shaft (firing order of the cylinders is 1, 2, 4, 3).

lution of the crank shaft, and a twelve-cylinder engine gives six effective strokes.

How the Valves Are Worked.—To make the inlet and the exhaust valves open and close at the right in-

stant *timing gears* are used as shown in Fig. 29. The small gear is keyed to the end of the crank shaft, and the other gear, which has twice the number of teeth on it as the small driving gear, is keyed to the end of the cam shaft.

Two cams are mounted on the cam shaft for each pair of valves, since there is an inlet and an exhaust

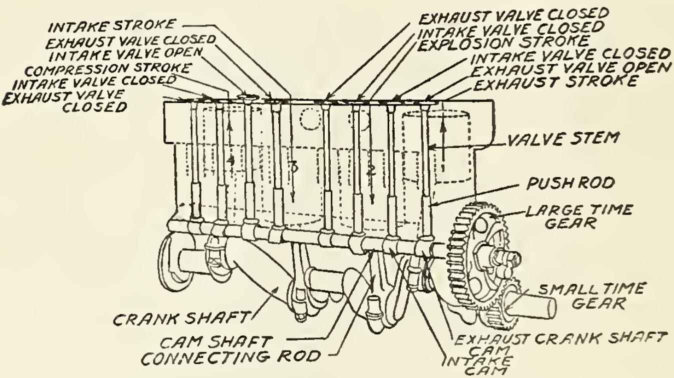


Fig. 29.—Timing gears, cam shaft and valves of a Ford engine.

valve in each cylinder. The various positions of these cams as they turn with the cam shaft are shown in the diagram Fig. 30, during the four strokes of the piston. The cams working the inlet and exhaust valves are shown as mounted on separate cam shafts in order not to confuse, but they are more often all mounted on the same cam shaft.

Timing the Valves.—To make the engine efficient it stands to reason that the inlet and the exhaust valves must open and close at precisely the right moment. But

the *right moment* does not mean that the valves must open and close when the piston is at the exact end of its stroke, or on its *dead center* as it is called, but on the contrary, they must open and close a little *before* and a little *after* the end of the strokes and this is called the *lead* and the *lag* of the valves.

Thus in order that the burnt gases can be pushed out with the least resistance possible by the piston on

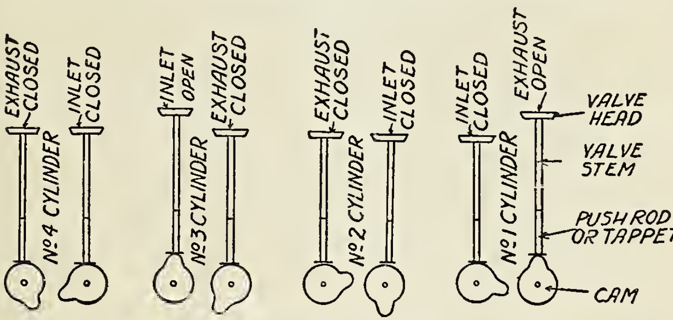


FIG. 30.—Diagram of how the cams work the valves (firing order is 1, 2, 4, 3).

its exhaust stroke, the exhaust valve must lead a little before the power stroke is finished. Again the exhaust valve when it is open must lag after the piston begins to move down on its suction stroke so that every particle of the burnt gases can be *scavenged* and got out of the cylinder. The exhaust valve then closes and the inlet valve opens and draws in the fuel mixture.

In turn the inlet valve must lead, that is, remain open, while the piston is making, say, the third of its compression stroke in order that a larger quantity of the fuel mixture may flow into the cylinder.

The Exhaust Gases.—In the same way and for the same reason that a gun makes a report when it is discharged the exhaust of an engine makes a loud noise; in either case it is because the burnt gases are driven out at high pressure into the lower pressure of the air.

To do away with this noise a *muffler* is used, that is, the exhaust gases from the cylinder of the engine are

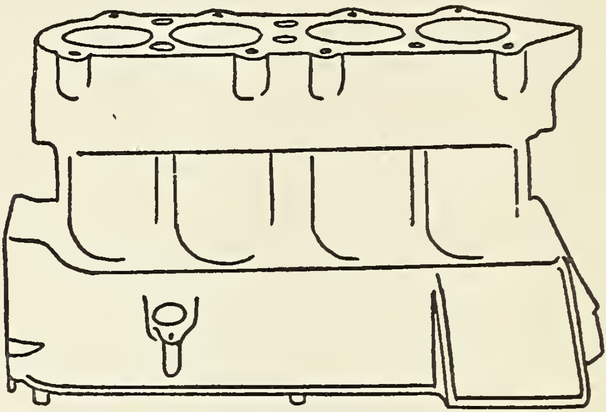


FIG. 31.—Four cylinders cast *en bloc.*

made to flow through the exhaust pipe into a series of tubes, or around a spiral, before they reach the air, and by this means the gases are reduced to the pressure of the air, when they are then discharged into it.

How an Engine Is Built.—*The Cylinders.*—The cylinders of gasoline engines are made of cast iron. It is the usual practice to cast four cylinders *en bloc,* that is, all in one piece, as shown in Fig. 31, while six-cylinder engines are generally cast in threes as well as in blocks.

Where the valves are all set in the head of the engine it is said to be of the I type; where they are all set on one side of the engine it is termed an L type, and where the inlet valves are on one side and the exhaust valves on the other it is known as the T type. The *water jacket* is usually cast around the cylinders, though it is sometimes cast separately. In Fig. 32, A

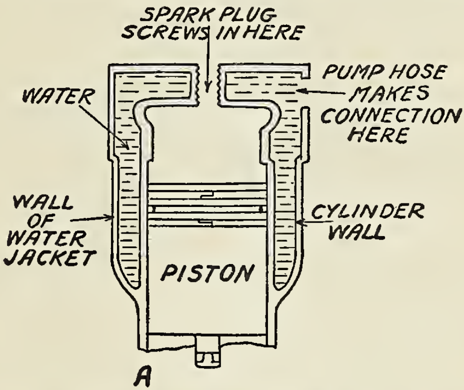


FIG. 32.—A. Water jacket cast integral with cylinders.

shows how the water jacket is cast on a four-cylinder engine in one piece.

The Pistons.—Since a *piston rod* with its cross head guide block is not used in the gasoline engine as it is in the steam engine, the piston must be made much longer so that it will slide true and even; as a rule its length is a little larger than the diameter of the cylinder. Near the closed end of the piston three or more grooves are cut on the outside wall or surface of it.

Piston rings are also made of cast iron and cut through when they are slipped over the piston into the

grooves as shown at B. A pair of projections, or *bosses,* are cast on the inside of the piston and a hole is bored through them transversely for the *wrist* or *piston pin;* on the latter one end of the connecting rod is fitted.

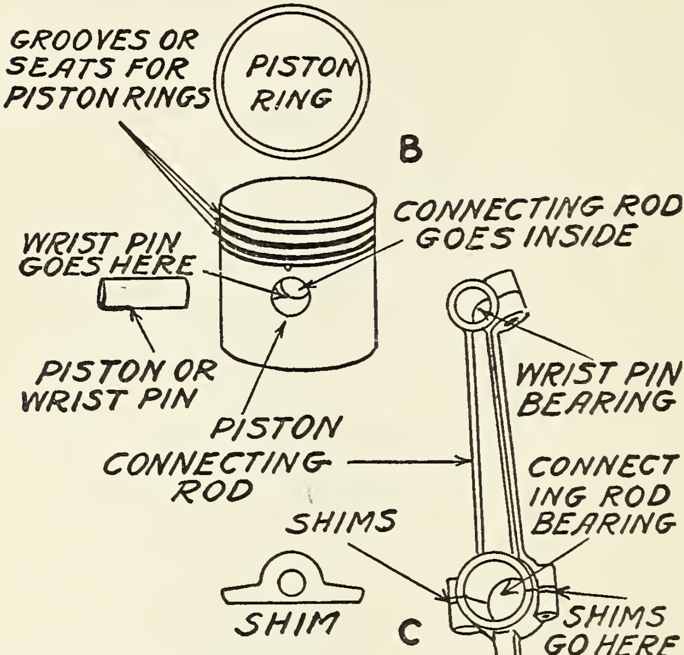


Fig. 32.—B. Piston, piston ring and wrist pin. C. Connecting rod and shim.

The Connecting Rod.—This is the rod that connects the piston to the crank shaft; it is generally made of pressed steel having an I cross-section to make it strong and at the same time light. A hole is bored through the top end for the *wrist pin* while the bottom end has

a *babbitted bearing* for the *crank-pin;* it is shown at C.

The Crank Shaft.—The crank shaft in all good engines is made of a single piece of drop-forged vanadium heat-treated steel. In both the four- and six-cylinder engines there is a bearing between the cranks in the middle of the shaft, as shown at D, to relieve the twisting stress to which it is subjected.

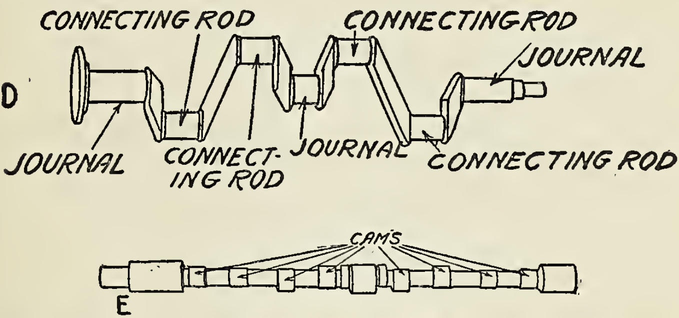


FIG. 32.—D. A four-cylinder crank shaft. E. A four-cylinder cam shaft.

This shaft is mounted in large babbitted bearings. A *driving cam gear* is slipped over and keyed on the forward end of the crank shaft while the extreme end is slotted to engage a hand crank for cranking the engine. The rear end of the crank shaft carries the flywheel.

The Cam Shaft.—This is simply a straight steel shaft with a timing gear on one end which meshes with the timing gear on the crank shaft, and on which the cams are set as shown at E. In some cam shafts the cams and the shaft are made of one piece and in others the cams are keyed on to the shaft.

The Inlet and Exhaust Valves.—The *valve heads* are

made with beveled edges and fit into holes called *seats* in the inlet and exhaust ports of the cylinder.

The valve heads should be made of *tungsten steel* to prevent the gases from warping and pitting them. Each head has a *pop* cast on it to enable the valve to be ground. The valve head is fixed to the end of a *valve stem* as

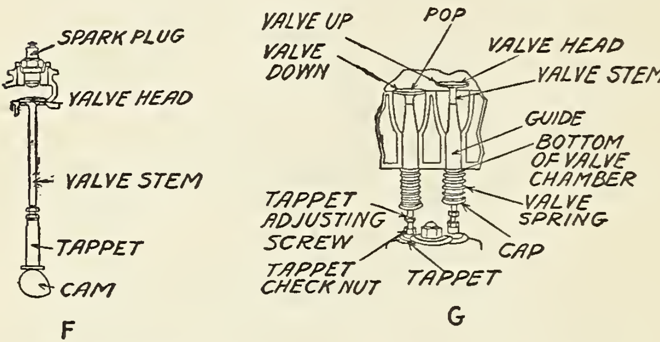


Fig. 32.—F. A poppet valve. G. How the poppet valves are set.

shown at F and this slides through a *valve guide* as shown at G.

To make the valve close quickly after it is released by the cam, a spring is slipped over the stem and rests on a cap on the lower end of the stem while the upper end of the spring rests on the lower side of the valve chamber. The valve stem sets on a *tappet* or *push rod,* and this rests on the cam.

The Manifolds.—These are the branched pipes that carry the fuel mixture into, and the burnt gases out of the cylinders. The inlet manifold connects the carburetor with the inlet ports of the cylinders and the

exhaust manifold connects the exhaust ports of the cylinders which end in the muffler.

The manifolds are joined to the cylinders by putting a *gasket,* that is, a washer made of asbestos or composition packing, between the ends of the pipes and the ports when they are bolted together to make gas-tight joints.

The Muffler.—There are many kinds of mufflers, but as simple a one as any is formed of three or more tubes

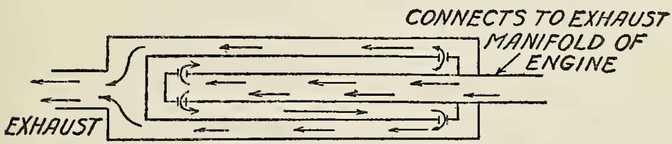


FIG. 32.—H. One kind of a muffler.

placed inside of each other as shown at H. These tubes have holes in opposite ends so that the gases flow in and around the pipes and from one pipe to the other through the holes and this breaks the force of them before they finally exhaust into the air.

Diseases of the Engine and How to Cure Them. —*When the Engine Won't Start.*—This may be due to poor compression and poor compression may be due to (1) leakage of foot piston caused by scored cylinder walls. (2) Defective rings. (3) Leakage through valves. (4) Piston rings that are stuck in their seats; to free the rings pour a couple of tablespoonfuls of kerosene into each cylinder through the *priming cocks,* and let it stand overnight. (5) Should the valve head, or its seat, be warped the remedy is to grind the valve. (6) Valves

that are not properly timed will also result in poor compression. (7) If the cylinders need oil there will be loss of compression; put in a fresh supply of oil and crank the engine by hand until the compression is good. (8) A stuck inlet valve makes the engine act as if it lacked compression; release the valve head and see if the spring is weak or broken; if weak, stretch it.

When the Engine Smokes.—(1) This may be due to either worn or broken piston rings; (2) stuck piston rings will also cause it, in which case free it with kerosene oil as above.

When the Explosions are Regular but Weak.—This may be caused by either (1) loose valves, when they should be reground, or (2) by weak valve springs, which should be stretched, or (3) by too small a lift of the exhaust valve; fix this by having a space between the lower end of the valve stem and the upper end of the push rod when the valve is on its seat and the push rod is in its lowest position.

When the Engine Hisses.—(1) See that the priming cock of the cylinder is closed; (2) that the exhaust pipe is connected tight to the manifold; if not tighten the bolts or put in a new gasket; (3) that the inlet manifold does not leak; (4) *scored* cylinder walls, that is, a cylinder which is scratched by a broken piston ring, or running the engine without oil, in which case the cylinder must be reground or a new one put in.

When the Action of the Engine Is Irregular.—(1) A leaky manifold may account for it, also (2) either worn or broken piston rings.

When the Engine Misfires.—A valve may be stuck.

When the Engine Overheats.—May be caused by (1) the engine racing or being run too long on low gear; (2) by the valves not being timed right; (3) the exhaust pipes stopped up; (4) the exhaust valves do not raise high enough and (5) a choked muffler, when the soot should be cleaned from it.

When the Engine Knocks.—This results from (1) carbon deposits caused by premature ignition; clean out the carbon from the cylinder and clean the piston rings; (2) loose or worn bearings; tighten and renew them; (3) a loose flywheel and (4) a loose cylinder or crank case, both of which should, of course, be tightened up.

When Explosions Occur in the Muffler.—Sometimes this is caused by (1) an exhaust valve leaking, (2) the muffler being clogged up, or (3) by good gas getting into the muffler and fired by the next discharge.

How to Calculate the Horse Power of Your Engine.—To find how many horse power your engine develops use this formula:

$$\text{H. P.} = \frac{D^2 \times N}{2.5}$$

Where H. P. is the horse power wanted;

D^2 is the bore or diameter of the cylinder squared,

N is the number of cylinders and 2.5 is the *coefficient.* For example, suppose the bore of each cylinder of your engine is 3¾ inches and there are six cylinders, then

$$\text{H. P.} = \frac{3.75 \times 3.75 \times 6}{2.5} \text{ or}$$

$$\text{H. P.} = \frac{84.4}{2.5} = 33.8 \text{ or}$$

$$\text{H. P.} = 33.8$$

Note.—The coefficient 2.5 has been determined by experiment and calculation to be accurate for the average engine having a piston speed of 1,000 feet per minute.

The Latest Word in Engines.—Out of 159 makes of passenger cars the engines in 61 of them have four cylinders; 1 has five cylinders; 74 have six cylinders; 18 have eight cylinders, and 5 makes have twelve cylinders.

Whatever the number of cylinders, the valves of all these engines operate on the principle of the four-cylinder engine, except the Knight, which will be described presently. The advantage of increasing the number of cylinders is that they can be made smaller and hence the speed greater, which gives increased power; this means greater *road ability,* that is, the engine can be accelerated in a shorter time and can negotiate the steepest hills and will not balk on sandy roads. Multi-cylinders also tend to mitigate vibration and besides they are accounted very economical.

The only five-cylinder engine that I know of is the *Eagle-Maccomber* and in which the cylinders are cast

singly. The cylinders of the *sixes* are usually cast in pairs and engines of this type are very popular as the above figures show. Eight- and twelve-cylinder engines are something of an innovation. The *eights* are often cast *en bloc;* all are of the V type, that is, 4 cylinders on each side form an angle like the letter V.

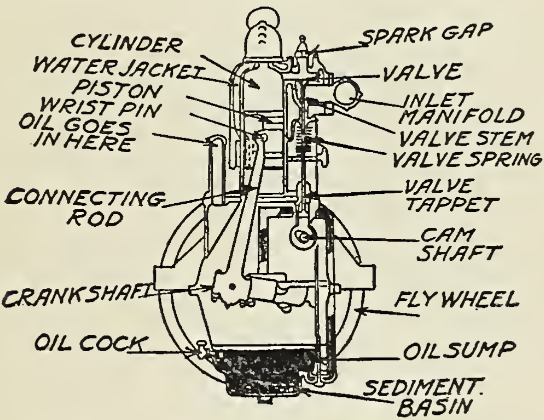


FIG. 33.—Cross section of a gasoline engine.

Some of the best cars like the Peerless, Haynes, Hal (Lozier) are engined with *twin sixes* as the *twelves* are called.

In the *Knight* engine the inlet and exhaust ports are opened and closed by *sleeve valves* that slide up and down between the piston and the cylinder wall and this does away with the poppet valves and cams that work them.

CHAPTER V

HOW THE GASOLINE SYSTEM WORKS

Knowing now how the engine is made and works in-so-far as its mechanical construction is concerned, the next thing to find out is how the gasoline is taken from the tank, how it is converted into the fuel mixture and how it is drawn into the cylinders.

What the Fuel System Is.—The gasoline system, or *fuel* system as it is more properly called, is formed of two chief parts and these are (1) the *tank* on the car in which the gasoline is carried and (2) the *carburetor* which mixes the gasoline with the right proportion of air and changes it into an explosive gas called the *fuel mixture.*

The Simplest Form of Carburetor.—To begin with, let's take it for granted that there is a supply of gasoline in the tank and that it will flow freely into the carburetor, and let's go into the matter of the carburetor first, because when you understand how this miniature gas plant makes the explosive mixture everything else about the fuel system will be as clear as crystal.

To learn all about how a carburetor is made and how it works I will build up one for you in words and with pictures step by step so that you will be easily able to visualize it.

First, suppose you have a tank of gasoline and a pipe

joined to it which ends in a nozzle with a very small opening as shown at A in Fig. 34; then of course the weight of the gasoline in the tank will make it squirt

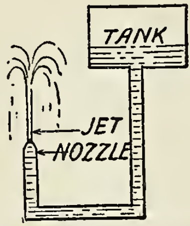


FIG. 34.—A. How the nozzle forms a jet.

from the nozzle in a stream upward and when the jet finally breaks the gasoline will fall back again.

To make a spray of the gasoline a stream of air must

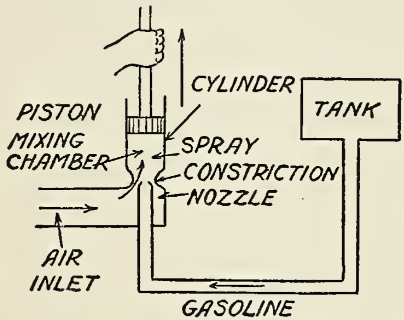


FIG. 34.—B. How a spray of gasoline is made.

be mixed with it and the way to do this is to enclose the nozzle in a larger tube which has a constriction in it at the jet as shown at B to give the air a higher pressure; this kind of a tube is called a *Venturi* tube.

Now while the gasoline will flow through the nozzle as before it will not form a spray until the air is sucked in through the air inlet tube and when this is done it will mix with the gasoline and the high pressure will break the latter up into very fine particles.

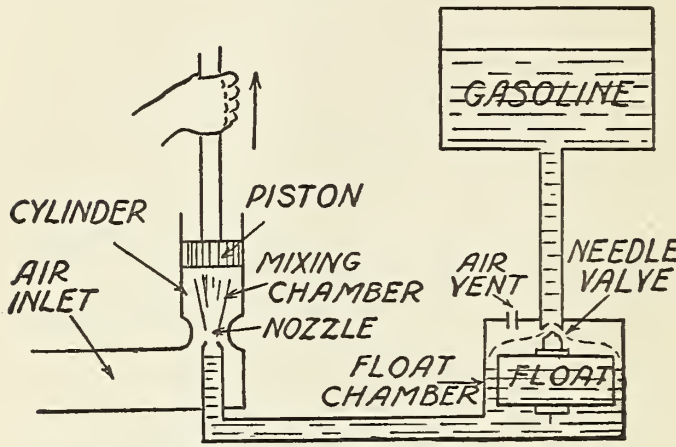


FIG. 34.—C. Diagram showing how a carburetor works.

An experimental way to suck the air through the tube is to pull back a piston in a cylinder which is connected to the mixing chamber as shown at B. Another way is to connect the mixing chamber to the inlet port of the cylinder of the engine and then when the piston makes its suction stroke it will draw the fuel mixture into the cylinder.

How the Carburetor Is Made and Works.—But there is a great deal more to a carburetor than merely a device which will mix the air with the gasoline in a spray, for the amount of gasoline that flows through

the nozzle and the quantity of air that is mixed with it must be very accurately gauged and regulated and, moreover, all of this should be done automatically.

To accomplish this successfully the *float valve* was invented; this arrangement is pictured in a very simple form at C and a glance at the sketch will show that it consists of (1) a *float chamber* connected in between the gasoline tank and the nozzle; (2) a cork, or a hollow metal *float* and (3) a *needle valve.* The end of the supply pipe that opens into the float chamber contains the needle valve which is opened and closed by the float according to the amount of gasoline there is in the chamber.

It must be plain now that when the gasoline in the float chamber has reached a certain level it will raise and close the valve, and that as the engine sucks in the fuel mixture the float in the float chamber will fall and so open the needle valve and allow more gasoline to flow into the float chamber again.

In this way a constant supply of gasoline is furnished to the nozzle automatically, the exact amount depending entirely on the requirements of the engine.

The Construction and Operation of a Real Carburetor.—A carburetor that is built for actual use is made and works on precisely the same principle as the simple one I have just described, but there are a few more detailed points to it.

For instance there is an *auxiliary air valve* opening into the mixing chamber as shown at A in Fig. 35; the purpose of this extra valve, which is kept closed by the spring and when more air is needed is opened by the

outside pressure of the air, is to allow more air to be mixed with the spray in the mixing chamber than can

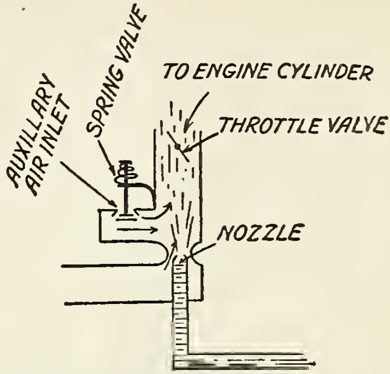


Fig. 35.—A. The auxiliary air inlet of a carburetor.

get through the main air inlet and this permits a *rich* or a *lean* mixture to be had. A rich mixture, be it

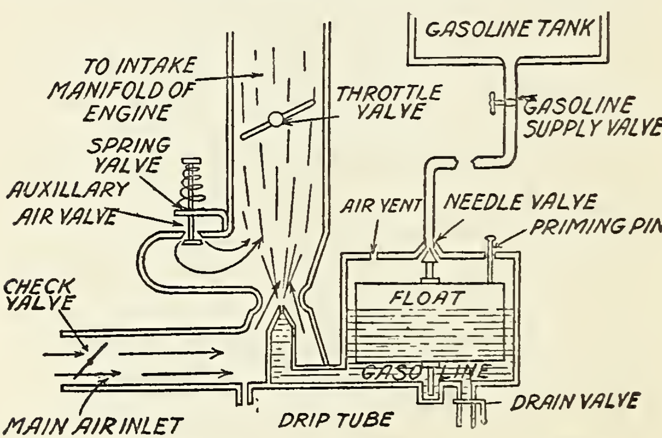


Fig. 35.—B. The carburetor complete in cross section.

known, is one in which there is very little air and a lean mixture is one in which there is very little gasoline. A cross section of a complete carburetor given at B and C shows how it is connected to the cylinder of an engine.

In commercial types of carburetors the needle valve

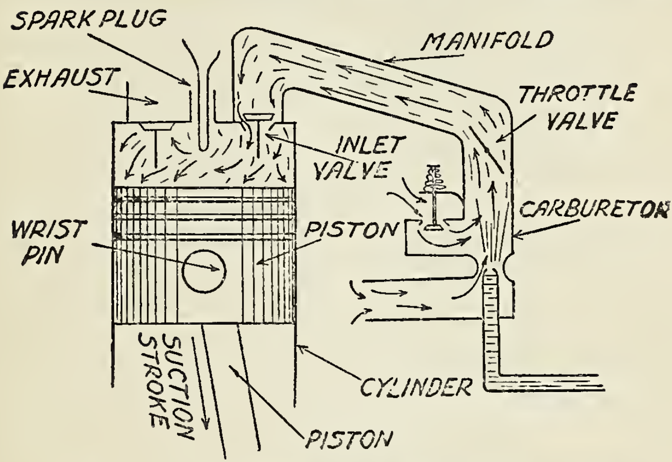


FIG. 35.—C. How the carburetor is coupled to the engine.

is often placed under the float and as the float rises and falls it lifts and lowers a weighted lever which is attached to the needle valve; again in others the spray nozzle is fixed in the center of the float chamber and passes through a hole in the float; it works the needle valve which is placed outside of it by means of a couple of levers as shown in the cross-section view of the Stromberg carburetor at A in Fig. 36 and the same carburetor is shown complete at B.

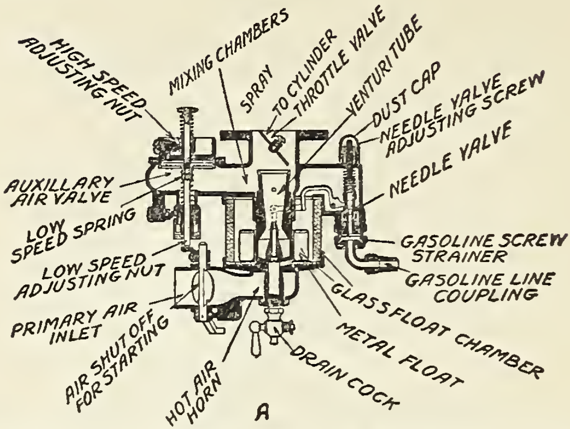


Fig. 36.—A. Cross section view of a Stromberg carburetor.

A rich mixture is needed to start the engine easily and so each carburetor has a *priming pin* fixed to the float so that the latter can be pressed down and the

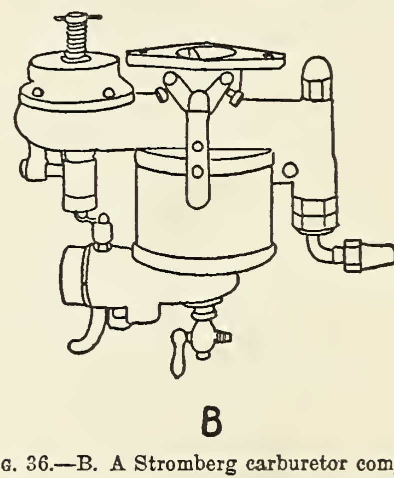


Fig. 36.—B. A Stromberg carburetor complete.

needle valve opened, see B in Fig. 35, which *floods* the carburetor, that is, a stream of gasoline will spurt from the nozzle into the mixing chamber.

In the older kinds of carburetors the *check valve* in the main air inlet was fixed and this made priming necessary, but in recent models the check valve can be closed by a button on the dash and as this shuts off the air a rich mixture is had.

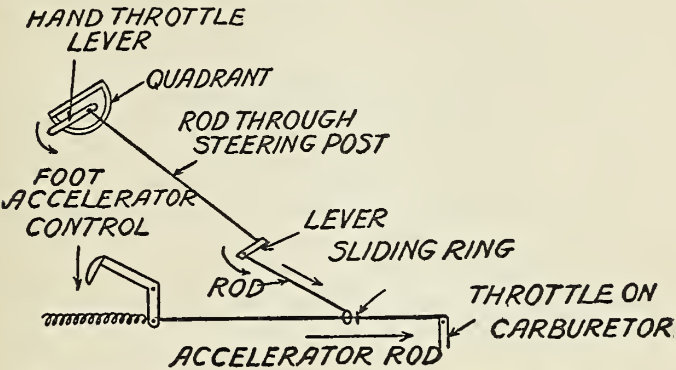


Fig. 37.—Throttle lever and accelerator controls of carburetor.

A *drip tube* opens from the main air inlet to let out any gasoline that may happen to overflow from the nozzle and a *drain cock* is provided at the bottom of the float chamber to drain off the gasoline when you want to.

When the carburetor is installed on the engine the throttle valve in the head of the mixing chamber is connected to a throttle lever on the steering post, or to an accelerator pedal, or, better, to both, and the way this is done is shown in Fig. 37.

About Air and Gasoline Heaters.—To get the best results all of the gasoline that passes through the carburetor must be completely vaporized and the way to do it is to *pre-heat* the gasoline, or the air, or both, in the carburetor.

In some carburetors a jacket is built around the float chamber or the mixing chamber and this is connected with the water system so that the water heated by the engine will flow around it, or else it is connected to a pipe around the *exhaust* manifold when the air will circulate through it and so becomes hot.

A separate attachment, called an *air heater,* can be bought and fitted to any carburetor. This heater is formed of a tube, or *housing,* around the exhaust pipe and a smaller flexible tube carries the air so heated to both the primary and the auxiliary air intakes of the carburetor. The heated air passes through the spray nozzle and mixing chamber and this more completely vaporizes the gasoline, which, of course, produces a more explosive mixture.

Kinds of Fuel Feed Systems.—*The Gravity Feed System.*—In this system the tank is placed above the level of the carburetor, usually under the front seat, and the gasoline simply flows down through a pipe into it by the gravitational pull of the earth upon it. It is shown in the preceding pictures, Figs. 34, 35 and 36.

The Air Pressure Feed System.—In this system the gasoline tank is placed on or below the level of the carburetor at the rear end of the car. To make the gasoline flow into the carburetor a small *air compressor,*

or *pump,* is used to pump air into the tank, as shown in Fig. 38.

When the gasoline is under a pressure of from one to four pounds it will force the gasoline up through the pipe and into the carburetor. Two pumps are used on most cars equipped with this system, and these are (1) a *hand pressure* pump to be used when the engine is stopped and there is no pressure showing on the gaso-

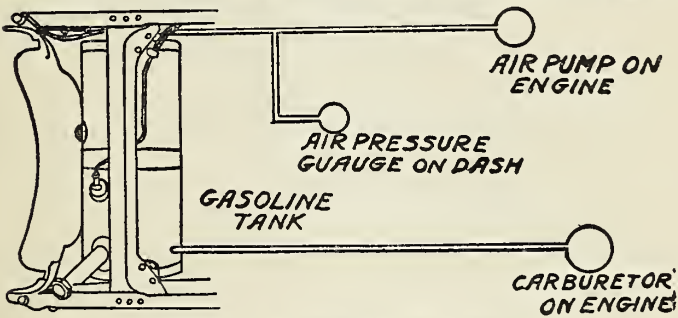


FIG. 38.—The pressure feed system.

line gauge, and (2) a *power pressure pump* which supplies a constant pressure when the engine is running.

The Vacuum Feed System.—In this system the gasoline supply tank is placed on the rear end of the car below the level of the carburetor as in the pressure system, but instead of the gasoline being forced under the pressure of the air, it is *sucked* from the supply tank into a small fuel tank which is placed on the dash or fixed to the engine by the *vacuum* set up in the latter tank by the suction stroke of the pistons.

That is, the small fuel tank is connected to the inlet manifold of the engine and then by means of valves and

a float operating very much like those in a carburetor the suction pulls the air out of the small vacuum tank, when of course the ordinary atmosphere pressure on the gasoline in the supply tank forces it into the small tank.

When the small tank is full enough the float closes the suction valve and the main supply is cut off. A

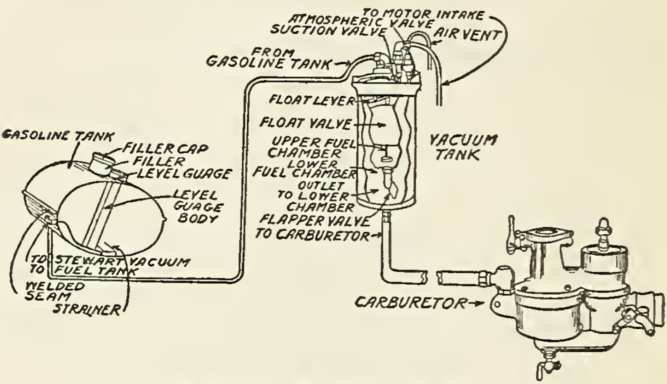


Fig. 39.—The vacuum fuel system.

pipe connects the bottom of the small tank to the carburetor, and the latter is supplied with gasoline by gravity feed, all of which is shown in Fig. 39.

What Carburetion Means.—It is not only necessary to have the correct proportions of gasoline and air which form the fuel mixture for the different speeds at which the engine runs, but the complete vaporization of the gasoline is of even greater importance, and the different qualities of gasoline now sold make this a hard thing to do.

In the early days of the gasoline engine motor car

the same mixture of air and gasoline was used for all speeds, but experiments have shown that the greatest economy is had when the mixture is varied according to the speed.

A *rich mixture* gives the best results when the car is running on the low speed gears or when it is hauling heavy loads; the reason for this is that the mixture burns much slower, the compression is poorer and there is a large loss of heat by the cylinders.

A *lean mixture* should be used at high speeds and when the load is light because the combustion of the mixture is then very rapid, the compression is better and there are small heat losses in the cylinders.

If heat is applied to the gasoline, or the air, or to both, before they pass into the mixing chamber the spray is *vaporized,* that is, it takes on the form of a gas, when it becomes at once a more efficient explosive mixture and hence is far more economical. Further the fuel mixture must be heated to the right temperature to give the best results, for on this *critical temperature* depends to a very large extent the smooth running of the engine.

About Buying Gasoline.—Crude petroleum is an oily liquid obtained from the earth and when it is heated it gives off various products in the form of vapor, such as kerosene, naphtha, benzine and *gasoline.* Gasoline can also be made from natural gas.

There are three kinds of gasoline and these are (1) *straight refinery* gasoline; (2) *blended casinghead* gasoline and (3) *cracked,* or *synthetic* gasoline. Straight gasoline is made by distilling crude petroleum

and when its *specific gravity*[1] reaches a certain mark the heat is cut off. This kind of gasoline is quite free from harmful hydrocarbons and is the very best for motor car engines.

Blended casinghead gasoline is made from *wet* natural gas by processes of compression and absorption; it is then *blended,* that is, mixed, with a heavy naphtha, and it is hard for the ordinary observer to tell the product so obtained from straight gasoline. Cracked, or synthetic gasoline as it is called, is made of blends of straight refinery with natural gas gasoline and this usually contains harmful compounds. This kind of gasoline is sold in enormous quantities.

The chief way to test gasoline is by its specific gravity, and this can be found by using a *hydrometer* having a *Baumé* scale. The highest grade has a specific gravity of 70 degrees Baumé or over and this is generally used for aëroplane engines; the middle grade should be used in engines built two or more years ago, and this ranges from 65 to 70 degrees Baumé. The third grade is around 60 degrees Baumé; it is the kind now largely sold in the Eastern market and is all right for up-to-date engines. The specific gravity of gasoline does not however check up accurately with its volatility and there you are.

To be on the safe side buy Standard, Texas or Gulf gasoline.

Troubles with the Fuel System and How to Fix Them.—*Testing the Carburetor.*—If the trouble is with your gasoline system push the priming pin down

[1] For more about *specific gravity* see any text book on Physics.

for a couple of minutes, and if the float chamber does not *flood,* that is, overflow, see if there is gasoline in the tank.

Should there be plenty of gas in the tank, examine the pipe line, and if this is clear the trouble must be in the carburetor and the remedies for fixing and adjusting it are as follows:

When the Engine Won't Start.—This may be caused by (1) a lack of gasoline in the tank; (2) the fuel mixture not proportioned right; this can be fixed by adjusting the air valves and needle valve that regulates the supply of gasoline so that the right amount of air and gasoline is mixed; and (3) water in the gasoline; when this happens run out all of the gasoline from the tank and put in a fresh supply, straining it through a chamois skin.

When the Engine Stops.—(1) This is another indication that the gasoline tank needs to be refilled, and (2) see that the carburetor is in working order.

When the Engine Knocks.—There are four reasons for this as far as the carburetor is concerned and these are (1) the fuel mixture is too rich; adjust the air and gasoline valves; (2) the carburetor float leaks and if it is a metal one solder it; (3) the cork float is waterlogged and if so dry it out and give it a thin coat of shellac; or (4) lint or other foreign matter may be under the float valve.

When the Explosions are Regular but Weak.—This is often due to (1) too lean a fuel mixture; either open the needle valve to give more gasoline or close up the air valves to give less air; (2) too rich a fuel mixture

in which case close the needle valve and open the air valves; (3) the auxiliary air valve may be out of adjustment; clean the valve and stretch the spring a little.

When the Action of the Engine Is Irregular.—This is sometimes caused by (1) too lean a fuel mixture and (2) too rich a fuel mixture; in either case the engine will misfire; if so adjust the needle and air valves; (3) water in the gasoline and this prevents the gasoline from getting through the spray nozzle; drain the tank and refill. A simple test to find if there is water in the gasoline is to drain a little from the bottom of the float chamber into your hand, blow on it to evaporate the gasoline and the water will remain behind if there is any in it.

When the Engine Races.—This is caused primarily by the throttle valve being open and incapable of adjustment; see (1) if the accelerator spring is broken; or (2) if any of the ball joints in the controlling levers have worked loose.

When There Is a Decrease in Power.—(1) The gasoline feed pipe to the carburetor may be clogged; if so unscrew the coupling of the pipe and carburetor and see if the flow is good; then examine the strainer of the carburetor; the nozzle may be choked up and the thing to do is to take it out and clean it.

When the Engine Misfires.—This is a good sign that (1) the gasoline tank is empty; (2) that the fuel mixture is too lean; or (3) that it is too rich.

When There Are Explosions in the Muffler.—This is often due to a lean fuel mixture and the result is that an unexploded charge escapes into the muffler and

the next charge fires it; give the mixture more gasoline.

Where the Fuel Power Goes.—It is a notorious fact that only 6½ per cent of the available 100 per cent of energy in the gasoline is actually used by the rear wheels in driving the car along and the other 93½ per cent of the energy is wasted in heat radiation, overcoming friction and air resistance.

The following table shows exactly where and how much these losses are:

Table of Fuel Losses.

Full Fuel Power of the Gasoline.	*Power Wasted by*	*Percentage.*
100 per cent.	Water Cooling	35.8
	Radiation of Exhaust Gas	34.6
	Exhaust Pipes	1.0
	Heat in Muffler	1.2
	Friction of Transmission	2.9
	Friction of Engine	5.6
	Friction of Rear Tires	3.7
	Friction of Front Tires	1.1
	Friction of Front Wheels	.6
	Resistance of Air	7.1
100%		93.6
	= 6.4% of available power.	

CHAPTER VI

HOW THE IGNITION SYSTEM WORKS

In all motor car gasoline engines an *electric spark* is used to *fire* the *fuel charge* in the cylinder and make it explode.

Kinds of Ignition Systems.—There are three kinds of electric ignition systems used to make the spark and these are (1) the *spark coil with a vibrator,* (2) the *high tension magneto* and (3) the *spark coil with a circuit breaker.* Many modifications of all these systems have been made, but when you know the fundamental principles you will easily understand them all.

The Vibrator Spark Coil System. — The first thing you must have to make a spark with this system is a *battery* to generate a current of electricity. Now there are two kinds of batteries used for this purpose and these are (1) the *dry battery* and (2) the *storage battery.*

The Dry Battery.—A dry battery is made up of two or more *dry cells* as shown at A in Fig. 40. Each cell is formed of a zinc cup in which are placed a carbon plate and an *active paste;* a binding post is fixed to the zinc and another to the carbon so that wires can be connected to them. When the chemical paste acts on the zinc it sets up an electric current having a large volume, that is, *amperage,* but it is under a very low pressure, or

voltage. When a dry cell is new it should deliver a current of from 15 to 20 amperes at a pressure of about

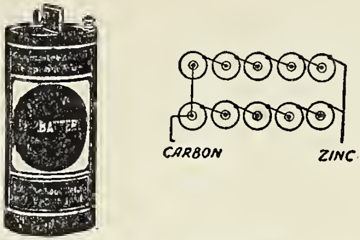


FIG. 40.—A. A dry cell and a battery of dry cells.

1.5 *volts.* Dry cells cannot be recharged to any purpose.

To Test a Dry Cell.—Hold the two terminals of an *ammeter* against the zinc and the carbon of the cell as

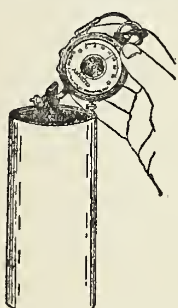


FIG. 40.—B. Testing a dry battery.

shown at B and the needle will point to the number of *amperes* that is flowing.

The Storage Battery.—A storage battery is made by immersing two plates of prepared lead, or *grids* as

they are called, in a jar filled with a weak solution of sulphuric acid, called the *electrolyte,* as shown at A in Fig. 41. It is shown ready for use at B.

Now a storage battery is different from a dry battery in that it has to be *charged* by a current from a *dynamo* before it can deliver a current, and this is the reason it is called a storage battery. A storage battery gives an

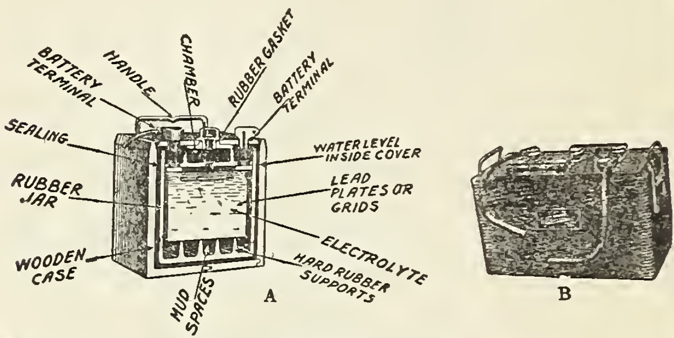


FIG. 41.—A. Cross section of a storage battery. B. Storage battery complete.

enormously large current on short circuit, while each cell gives a pressure of about 2 *volts.*

A dry battery is handier than a storage battery because you can buy new ones cheap when they are run down, whereas a storage battery must be taken to a regular station to be recharged unless you have a dynamo geared to the engine. But a storage battery is better than a dry battery because it delivers a more nearly constant current to the end, while a dry battery keeps petering out from the moment it is put to use.

To Test a Storage Battery.—Directions for testing

a storage battery will be found in Chapter IX under the sub-caption of *How the Current is Measured.*

The Vibrator Spark Coil.—Since both dry and storage batteries give a *low voltage* current and a *high voltage,* or *high tension* current as it is called, is needed to make a jump spark, a *spark coil* is used to raise the low pressure current to a high tension current. When the pressure has been *stepped up* the high tension current is carried to the *spark-plug* and, jumping across the gap, the spark is made.

There are five parts to a spark coil and these are (1) the *soft iron core* on which there is wound, but insulated from it, (2) the *primary coil,* formed of two or three layers of thick wire, and on this is wound, but also insulated from it (3) the *secondary coil,* which is formed of a large number of layers of very fine wire.

Then there is (4) an *interruptor,* or *vibrator* as it is more often called; this consists of a trembler which makes and breaks the current that flows through the primary coil from the battery several hundred times a minute, and, finally, there is (5) a *condenser,* which is built up of alternate leaves of tin-foil and oiled paper, all of which is shown in the diagram at A in Fig. 42 and as it really is at B.

How the Coil Makes the Spark.—When a current from a dry, or a storage, battery flows through the primary coil it magnetizes the soft iron core and this draws the *armature* on the vibrating spring to it and so breaks the contact points apart; this in turn breaks the primary circuit when of course the current from the battery is cut off. The iron core then loses its magnetism and lets

go of the armature when the spring flies back and closes the circuit again.

When a current flows in the primary coil another current is set up in the secondary coil by what is called *induction;* this secondary current only lasts a moment and when the vibrator breaks the primary circuit another momentary current is set up in the secondary coil which flows in the opposite direction to the first one.

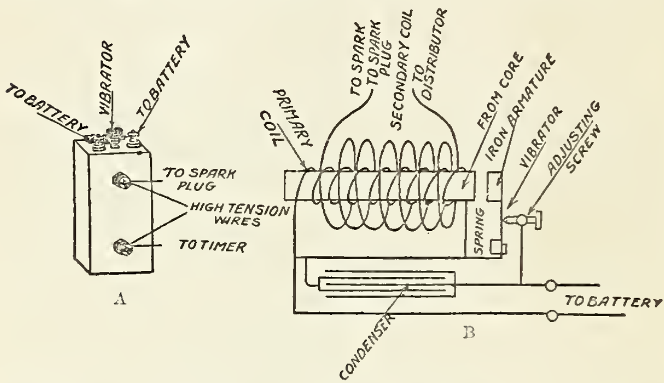


FIG. 42.—A. A spark coil. B. Wiring diagram of a spark coil.

As the vibrator makes and breaks the primary circuit several hundred times a minute *alternating currents* are set up in the secondary coil.

Not only this but the spark-coil steps up the pressure of the current for the reason that the primary coil has only a few turns of wire on it and the secondary coil has a large number of turns on it; the pressure is also raised by the *condenser* which is connected across the contact points of the vibrator. Thus the pressure of the current is raised until it can easily jump across an air

gap of ¼ inch, while the distance between the points of a spark-plug is only about $\frac{1}{25}$ of an inch.

How a Spark Plug Is Made.—If you will examine a spark plug you will see that there is only one place to connect a wire to it from the spark-coil or a magneto.

To save wiring, one wire of the spark plug is fastened to the thread of the metal *plug body* as shown at A and B in Fig. 43; the other wire runs up through

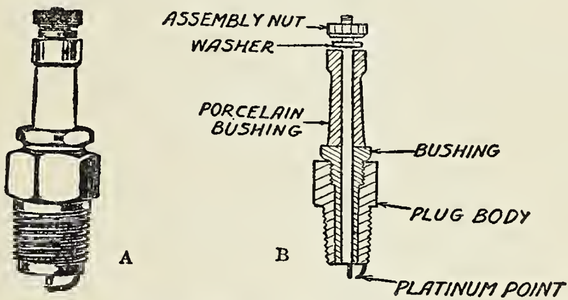


Fig. 43.—A. A spark plug. B. How a spark plug is made.

the *porcelain bushing* to insulate it from the plug body and on the end of this wire is a *thumb nut* to hold on the high tension wire.

As one of the spark gap wires is fixed to the plug body and the latter is screwed into the head of the cylinder the metal of the engine itself is used as a return circuit and, hence, the other wire of the spark coil, or magneto, can be connected to the engine itself, or *grounded* as it is called.

A Timer for a Single Cylinder Engine.—If a spark coil in action should be connected directly with a spark plug of course a continuous stream of sparks

would jump across the gap; if then you want to fire a charge in a single cylinder engine you must connect in a *timer,* that is, a mechanical circuit breaker as shown in Fig. 44, so that the spark will take place only at the end of the compression stroke.

It consists of an interruptor worked by a cam geared

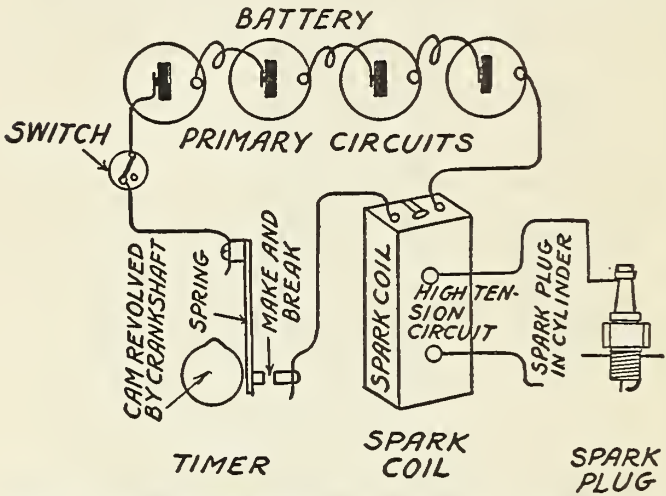


FIG. 44.—A spark coil, spark plug and timer for a one-cylinder engine.

to the crank shaft and at every revolution it presses the contact on a spring against a fixed contact and so closes the *primary circuit* at the right instant when a spark is made.

A Distributor for a Multi-Cylinder Engine.—When an engine has four or more cylinders there is usually a spark coil for each cylinder and these are mounted in a box on the dash; then, too, there must

be a separate fixed contact, or *segment* on the *distributor,* as the timing device is now called, for each spark plug in each cylinder, all of which is shown in the wiring diagram in Fig. 45.

When the arm revolves it *wipes* each of the fixed segments and this makes a spark successively and at

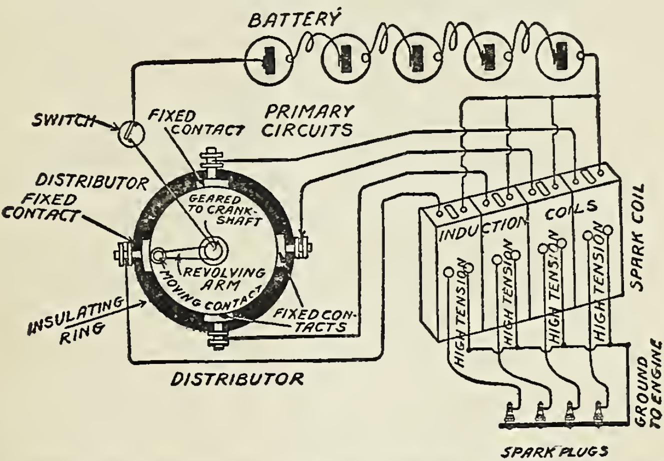


FIG. 45.—Four spark coils with spark plugs and distributor for a four-cylinder engine.

the right moment in each cylinder at the business end of the spark plug. The vibrator spark coil system is to be found only on old cars or on those of cheaper makes, the *magneto* and circuit breaker *spark coil* systems having displaced it.

The Magneto Ignition System: The Low Tension Magneto.—A magneto is different from a battery in that it generates an alternating current and also in that the current is of much higher tension.

In its simplest form it consists of a powerful U magnet as shown at A in Fig. 46, between the ends, *or poles,* of which an *armature* B is mounted so that it will revolve as shown in C.

The armature is made of soft iron with slots cut in it lengthwise and these are wound full of fine insulated wire to form a coil; the ends of this coil are fixed to a pair of copper rings called *collectors,* or *sliprings,* and

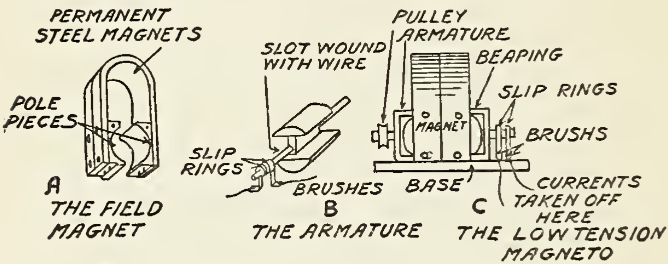


FIG. 46.—A low tension magneto.

these are mounted on, but insulated from, the shaft of the armature. A pair of flat copper springs called *brushes* are made to press on these rings so that they will take off the currents when they are generated by the armature.

How the Magneto Works.—Now as each turn of wire on the armature moves past each pole of the magnet it cuts the *magnetic field of force* and this sets up *alternating currents* in the coil; these currents flow through the coil to the sliprings where they are taken off by the brushes. This kind of a magneto is called a *low tension magneto* because the voltage is too low to make the current give a *jump spark.*

But if you will connect a low tension magneto to one or more spark coils instead of the battery shown in Fig. 45 the spark coils will set up jump sparks and you wll have a magneto ignition system very like the one used in the Ford cars.

The High Tension Magneto.—In order to step up the pressure of the currents set up in a magneto high enough to make jump sparks, a *second coil* is wound on the *first* coil of the armature exactly as it is in the spark coil previously described.

The Interruptor.—A make and break device made like the timer shown in Fig. 44 is fitted to the end of the magneto and this is connected in circuit with the primary coil.

A cam on the end of the armature shaft opens and closes the contact points as many times per revolution as there are cylinders to be fired. In one end of the armature is a small condenser and this is connected across the interruptor contact points. The armature then of a high tension magneto is really a spark coil which revolves and instead of a battery the primary current is produced by the armature spinning between the magnets.

In a high tension magneto one of the ends of the primary coil is *grounded* to the iron core of the armature and the other end is fastened to a slipring; thus only one brush and one slipring are needed as the circuit is completed through the magneto and the engine as shown at A in Fig. 47. The shaft of the armature is coupled to a counter-shaft which is geared to the crank shaft of the engine and so turns with it.

The Distributor.—As with the spark coil distributor the one used with a magneto consists of a revolving

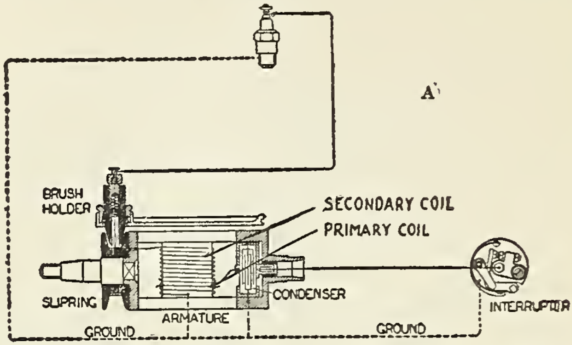
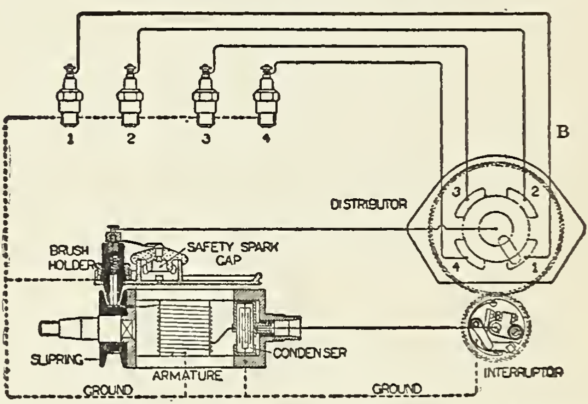


FIG. 47.—A. Wiring diagram of a high tension magneto and interruptor for a one-cylinder engine.



B. Wiring diagram of a high tension magneto, interruptor and distributor for a four-cylinder engine.

metal arm and as many metal segments fixed around it as there are cylinders to be fired, with a wire from each segment leading to a spark plug as shown at B.

The metal arm is set in an insulated disk and this is geared to the end of the armature shaft as shown in the Bosch magneto at C so that it will revolve and the arm make contact successively with the segments of the distributor plate. A large number of cars use magneto ignition solely.

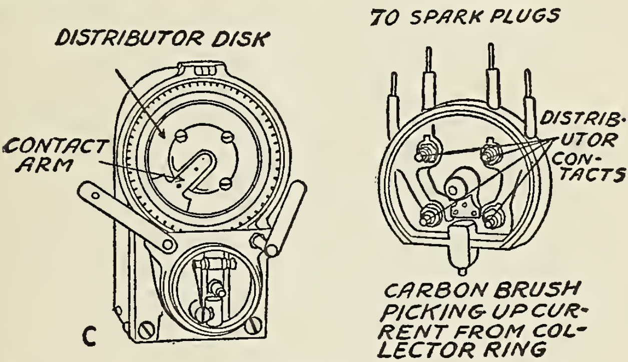


FIG. 47.—C. A high tension magneto showing interruptor and distributor disk and plate.

The Circuit Breaker Spark Coil System.—Since all up-to-date motor cars have both lighting and electric starting systems and as a storage battery is needed for their operation, makers have largely gone back to the spark coil ignition system.

In many of the medium-priced cars the spark coil system is now the only one used, while in the higher-priced cars the *dual system* is used, that is, they are equipped with both the spark coil and the magneto, so that if anything happens to one system the other is available.

In the new spark coil system, or *distributor system,*

as it is called, a spark coil is used as in the old one, but instead of having a vibrating make and break worked by the core of the coil, a *mechanical circuit breaker* just like the interruptor on a high tension magneto is used, and it is driven from a shaft geared to the engine in the same way.

The Spark Coil.—This coil has an iron core, a pri-

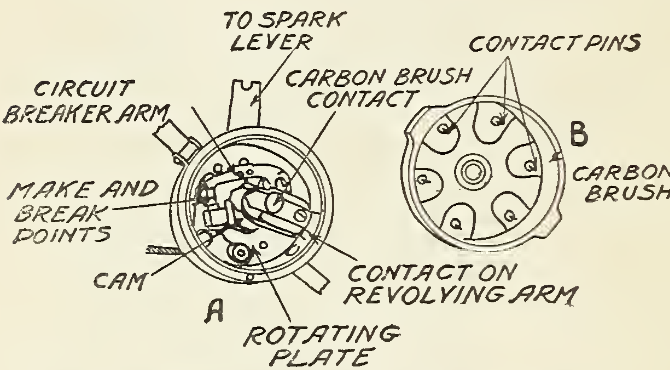


FIG. 48.—A. The circuit breaker and distributor combined.

mary and a secondary coil exactly like a vibrator spark coil.

The Circuit Breaker.—This device consists of a cam having as many projections on it as there are cylinders to be fired. This cam, which is mounted on a shaft, breaks the primary circuit every time a projection strikes the contact lever and this sets up a current in the secondary coil. A condenser is mounted on one end of the coil for convenience and it is connected across the contact points of the circuit breaker as in the vibrator of a spark coil and the interruptor of a high-

tension magneto. The circuit breaker and revolving arm of the distributor are shown at A in Fig. 48.

The Distributor.—The distributor is mounted on top of the *circuit breaker* and its revolving arm is fixed to the same shaft as the cam of the circuit breaker, but it

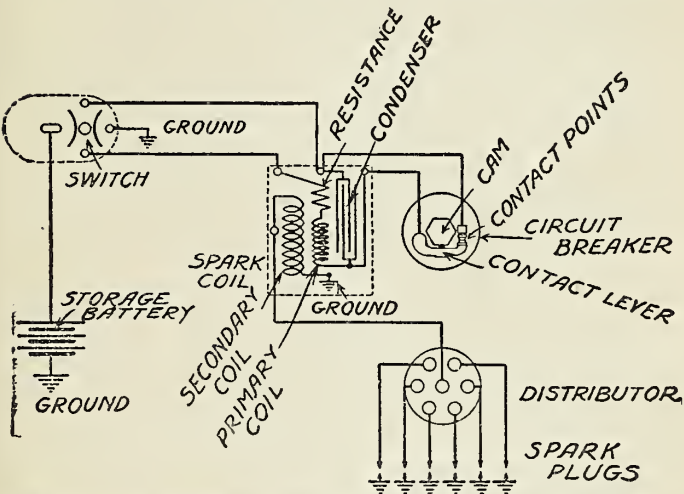


Fig. 48.—B. Wiring diagram of a six-cylinder circuit breaker spark coil system.

is well insulated from it. The revolving arm either makes contact with the segments of the distributor or, as in the Remy system, it just clears the pins which are used instead of segments, and a jump spark completes the circuit between them. The top of the distributor plate is shown at B.

The high tension current is led to the middle binding post and this connects with the revolving arm through a brush; the segments, or pins, connect with

the binding posts of the distributor and these are in turn connected with the spark-plugs as shown in the wiring diagram B and the pictorial diagram C.

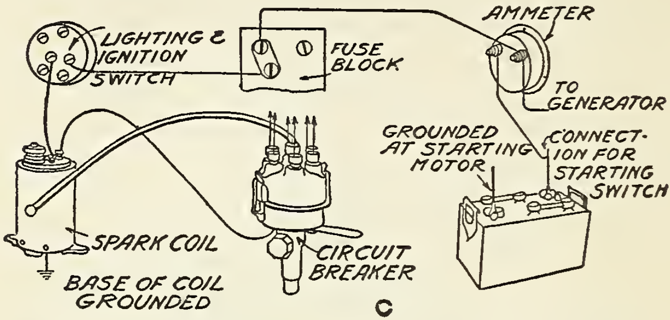


FIG. 48.—C. Pictorial diagram of a Remy six-cylinder ignition system.

Why the Spark Must Be Timed.—In the chapter on *How the Engine Works* I explained why it is necessary to *time* the valves so that there must be a lag or a lead to give the engine more power.

In the same way it is necessary to make the spark fire the charge just before the end of the compression stroke is reached in order to get the full power out of it, and this is what is meant by *advancing the spark.*

When the engine is cranked, especially if you do so by hand, the spark must be retarded, that is, it must not take place until after the piston has reached the extreme top of its stroke, or *dead center* as it is called, for if the spark takes place in advance of it, it will explode the charge and drive the piston back before it has reached the top and this reverses the direction of the crank shaft.

The reason the spark must be advanced when running is because it takes a small fraction of a second for the spark to ignite the whole charge and produce the explosion, and again as less gasoline is used on high speeds it takes even a longer time for the spark to explode it.

Hence if the spark is advanced so that it fires the charge before the end of the compression stroke it will not explode until the stroke is on the top dead center, or an instant after, and the full power of it is then obtained. But the spark should not be advanced too far because the explosion would then take place before the compression stroke was completed and this would cause a *back pressure* and cause the engine to knock.

To the end that the spark can be advanced or retarded according to the speed at which the engine is running, a control lever is connected to the *breaker box* of the circuit breaker so that the latter can be turned through an angle of about 30 degrees. The control lever is linked through jointed rods which run to and through the steering post to the spark lever on the steering wheel.

Disorders of the Ignition System and How to Treat Them.—*When the Engine Won't Start.*—Whatever system your engine is equipped with, look after (1) the battery switch and see that it is on; (2) test the dry battery with an *ammeter,* or if it is a storage battery, test it with a *voltmeter.*

(3) See that the wires are not broken and that the connections are clean and tight; (4) also look for a *short circuit,* that is, the insulation may be worn through and two wires or a wire and the engine may be touching each other; either put in a new wire, or tape

the old one; (5) examine the spark plugs and clean them if fouled with carbon, or replace them if cracked.

When the Engine Stops.—(1) Look for loose connections or broken wires; (2) the vibrator contacts may be stuck; if so, release and file them off flat to make a good contact; (3) poor contact in the timer; (4) not enough spark; this may be due to (a) a weak battery; (b) magnets demagnetized; (c) magneto breaker points out of adjustment; (d) vibrator on the coil out of adjustment, and (e) gap of the spark plug either too small or too large.

When the Engine Overheats.—This may be caused by (1) the spark being retarded too much; push the spark lever clear up unless the engine begins to knock.

When the Explosions Are Regular but Weak.—(1) This may result from the vibrator of the coil being out of adjustment, or (2) the spark plugs working loose.

When the Action of the Engine Is Irregular.—See if (1) the spark plugs are cracked or loose; (2) if the insulation on the wires and the connections are good, and (3) that the contacts of the vibrator or timer are clean.

When the Engine Knocks.—This sometimes results from the spark being advanced too much, in which case retard it a little.

When the Engine Misfires.—The spark plugs may be fouled, so clean off the carbon.

When the Engine Hisses.—A spark plug may be broken.

When Explosions Occur in the Muffler.—This is often caused by (1) the spark being retarded when it fails to

fire the charge in the cylinder, or (2) not enough spark to fire the charge, and (3) timer is out of adjustment; see that the batteries deliver current and clean the contacts.

CHAPTER VII

HOW THE OILING SYSTEM WORKS

The first step toward making a car run smoothly and last long is to keep every working part of it properly *lubricated.*

The last thing a demonstrator will do is to show you how to oil the engine, point out all the *grease cups,* and unless you give the engine its pro-rata of the right grade of oil and keep the grease cups all over the machine filled with grease, woe be unto you and your car.

The Parts of a Car to Be Oiled.—The five chief parts of a car to be lubricated are (1) the engine; (2) the clutch, if it is an oil immersed one; (3) the universal joints; (4) the transmission and (5) the differential.

Then there are many smaller moving parts all over the car that must be lubricated, but this is done through *compression cups,* or *grease cups* as they are commonly called, and these will be treated of further along in this chapter.

How the Engine Is Oiled.—Not only must the cylinders of the engine be supplied with oil, but all of the bearings and moving parts must be lubricated as well. As it is not a feasible scheme to oil the engine now and then by hand, some kind of an oiling system must

be used and it must neither supply too little nor yet again too much oil.

To provide a means to lubricate these hot and rapidly moving parts automatically the lower part of the engine is enclosed in a *crank case* and various arrangements, called *lubricating systems,* have been devised to supply each part with just the right amount of oil.

Kinds of Lubricating Systems.—Now there are two general types of lubricating systems and these are (1) the *splash* system, and (2) the *force feed* system.

In the *splash system* the oil is either poured into the crank case through a filler, or else it is fed into it by an oil pump from an outside reservoir. In this system the oil is splashed by dippers on the ends of the connecting rods striking it, which throw it to all parts of the engine.

In the *force feed* system the oil is put into the *crank case well,* or *sump* as it is called, that is, a reservoir below the floor of the crank case, and from there it is forced by a pump to the cylinders and other parts to be oiled and that portion which is not used drops back again into the sump.

Again, these two general types of lubricating systems can be divided into five distinct classes and these are (1) the *straight splash;* (2) *splash circulating;* (3) *splash and force feed;* (4) *force feed* and (5) *full force feed.*

The Straight Splash System.—The oil is poured into the crank case through a filler until it reaches the *splash level,* that is, a level on a line with the lower

ends of the connecting rods when they are on the lower dead center. A drain cock shows the proper level.

The connecting rods have dippers on their ends and as these strike the oil it splashes it onto the walls of the cylinders and on all of the bearings. It is shown

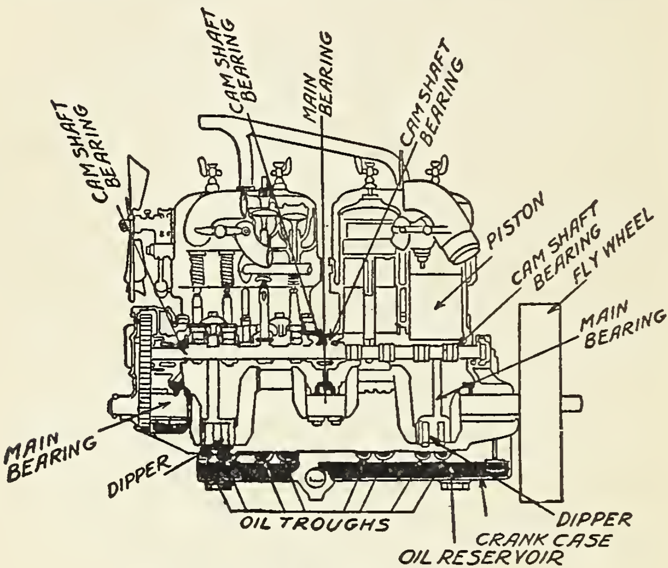


Fig. 49.—The straight splash system.

in Fig. 49. The *White* truck uses a simple splash system.

The Splash Circulating System.—This is also called the *semi-force feed* and *splash* system. In this system there is a *sump,* that is, a reservoir below the floor of the crank case, and this is filled to a given level; *splash troughs* are formed in the floor of the crank case and

these are kept full of oil by the centrifugal action of the flywheel, the overflow of the oil running back into the sump when it is pumped up again.

When the dippers on the connecting rods strike the oil in the troughs they splash it all over the cylinder walls, fill the oil cups on the main bearings and oil

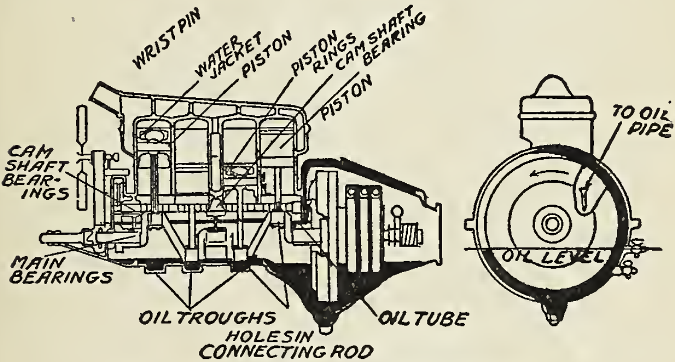


FIG. 50.—The splash circulating system.

all of the other bearings as shown in Fig. 50. The *Buick* uses this system.

The Splash and Force Feed System.—In this system the oil is forced by the pressure of a pump directly onto the crank shaft bearings; from these it falls to the splash troughs in the crank case into which the connecting rods dip when the oil is splashed to all the other parts of the engine, as shown in Fig. 51.

The oil is kept at a constant level in the splash troughs by an overflow to the sump and from this it is pumped up again. The oil is usually made to flow through a *sight feed* or to a *pressure gauge* so that you

can see that the system is operating properly. This system is used in the *Reo.*

The Force Feed System.—The oil in this system is contained in the sump and from this it is forced up by a pump to the main shaft bearings and then on through the crank shaft by means of *ducts,* or holes, drilled in the *crank webs* to the *crank pins.*

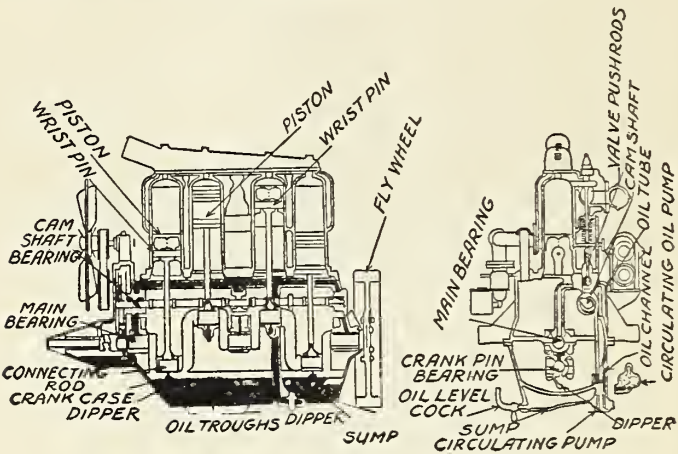


FIG. 51.—The splash and force feed system.

The surplus oil that flows through to the crank pins is thrown off by the lower ends of the connecting rods and this lubricates the cylinders, pistons and wrist pins. The excess oil falls into the sump again through an overflow or hole in the floor of the crank case. Fig. 52 shows the system and you will observe that the connecting rods do not dip into the oil. You will find a force feed system on a *Sterns-Knight* car.

The Full Force Feed System.—As in the force feed

system the oil is contained in the sump and from this it is forced by a pump direct to the main shaft bear-

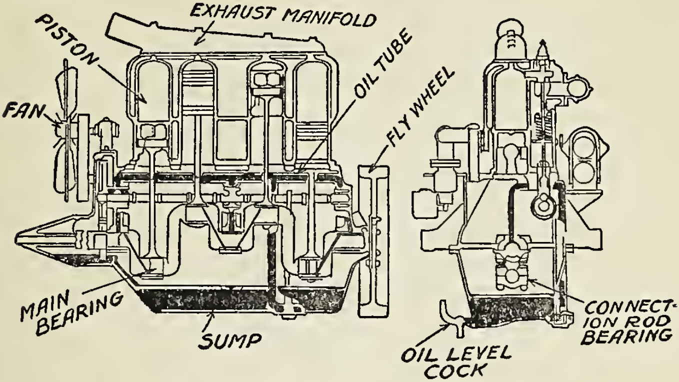


Fig. 52.—The force feed system.

ings and through holes in the crank webs to the crank pins, then on through oil pipes attached to the connect-

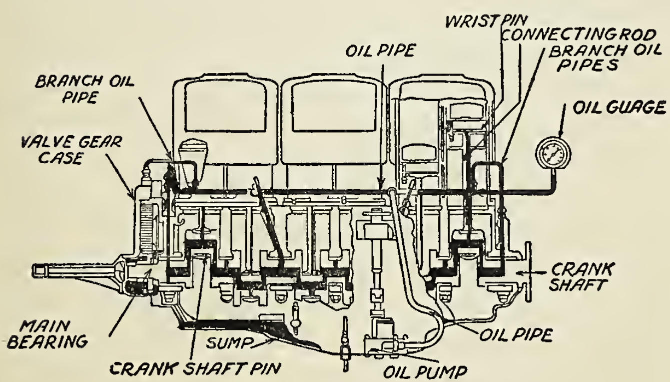


Fig. 53.—The fuel force feed system.

ing rods, or through hollow connecting rods, to the wrist pins.

Both the cylinders and pistons are supplied by oil thrown from the lower ends of the connecting rods as shown in Fig. 53. In some engines there is an extra lubrication of the cylinders supplied by oil flowing through the wrist pins and this is the only system in

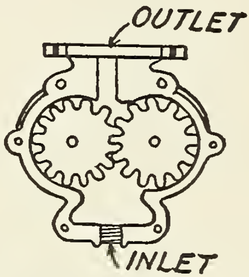


FIG. 54.—A gear oil pump.

which the lubrication of the cylinders is performed in this way. The *Pierce-Arrow* uses the full force feed system; indeed the force feed and full force feed systems are generally found on the highest-priced cars.

How the Oil Pump Is Made.—The gear type of oil pump is the most efficient and dependable for motor car engines and for this reason it is about the only one used at the present time for lubricating systems.

It works on the same principle as a water wheel with buckets on its rim, the oil being carried up by the teeth of the gears which run outward from the oil inlet as shown in Fig. 54.

Oil Pressure and Pressure Gauges.—The *pres-*

sure gauge is mounted on the dash of the car where it can be easily seen.

It is constructed like a steam pressure gauge, that is, it has a dial showing in figures the pressure in pounds to the square inch. A hand, or pointer, is connected by a series of levers to a spring against which the oil pressure acts and this moves the hand over the dial.

The pressure of oil varies according to whether the car is running slowly or is making fast time, and it also varies according to the engine used; for these reasons no hard and fast rule can be given.

About Engine Lubrication.—To get the best results every make of engine requires a particular grade of oil and some engine makers specify a certain make and grade of oil which you should use.

In any event the right oil for your engine must be one that will (1) lessen friction to the greatest extent; (2) it must have *body* enough to resist the high temperatures of the engine and form a film between the cylinder wall and the piston rings; (3) it must be fluid enough to flow freely in cold weather, and (4) it must be suited to the lubricating system of your engine.

When a poor oil is used, *scored* cylinder walls, as shown at A in Fig. 55, are almost sure to happen; carbon is bound to be found in the combustion chamber as shown at B and the piston rings will leak as shown at C. This is because the oil does not form a film between the piston rings and the cylinder walls and the rings not only leak but may scratch the walls.

If an oil that is too *light,* that is, without enough body, is used it will slip by the piston rings on the compression and power strokes and this not only results in loss of power, but some of it is deposited as carbon in the combustion chamber.

On the other hand, when an oil is too *heavy,* that is, when it has too much body, it will not form a film easily and again there is a loss of power.

Cheap grades of cylinder oil get gummy when heated and this causes a loss of power, makes the valves and

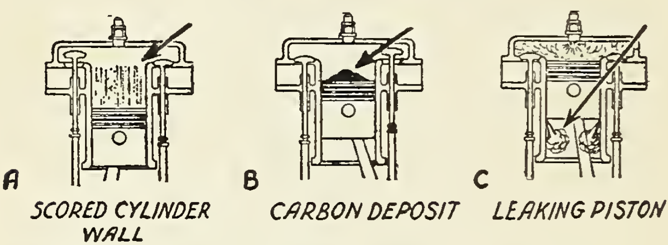


Fig. 55.—A, B and C. Troubles caused by using poor oil or wrong grade of oil.

piston rings stick in their seats and clogs up the oiling system. The moral is, buy a good bodied oil.

The Kind of Oil to Use.—A light or medium oil should only be used on an engine having a straight splash or a splash circulating system and in cold weather what is called a *cold test oil* should be used.

The force feed system also requires a medium bodied oil to properly lubricate the bearing surfaces, but in a few makes of engines the oiling system can be so designed that a heavy bodied oil can be used. An oil

having a medium or a heavy body should be used with full force feed systems and the oil supply can be varied by changing the pressure adjustment.

Great care should be taken in getting an oil of good quality and of the right body. When in doubt write the maker of your car, or the Vacuum Oil Company, 61 Broadway, or Platt and Washburn Refining Co., 11 Broadway, New York City.

What Lubricating Oils Are Made Of.—All lubricating oils for motor car gasoline engines are made from *petroleum,* the same crude earth oil from which gasoline is obtained. Chemically, lubricating oils are formed of hydrogen and carbon; there is also a lot of free carbon as well as other foreign matter in lubricating oils but these are filtered out. The carbon which is a constituent part of the oil cannot of course be taken away from it without changing the chemical nature of the oil itself.

When enough oxygen is present the carbon is burned up with the hydrogen and this is why it is necessary to have a vent, or *breather,* in the crank case. If too light an oil is used it gets into the combustion chamber, the hydrogen burns up and the carbon remains behind because there is no oxygen present for its combustion.

Troubles of the Oiling System and How to Get Rid of Them.—*When the Engine Won't Start.*—This is often caused by poor compression; test the compression by cranking the engine by hand; if it is poor (1) the piston rings may be stuck in their seats; to release them pour a little kerosene into the cylinders through

the priming cocks while the engine is warm and let it stay in them all night.

(2) A cracked spark plug will also cause poor compression, also (3) the valve heads, or their seats, may be warped, or (4) the valves may not be properly timed; these are jobs for you or the machinist; (5) poor compression may also result from a lack of oil in the cylinders; drain off the old oil, put in new oil and run the engine at cranking speed until the compression is good.

When the Engine Stops.—The cylinders may be dry, in which case put in a fresh supply of oil.

When the Engine Overheats.—This is sometimes caused by the lack of oil, or the use of oil that is not suited to the engine.

When the Explosions are Weak but Regular.—This may be due to the lack of oil; pour a little oil into each cylinder and then crank the engine by hand; open the drain cock and let the old oil and kerosene run out and then put in new oil and run at cranking speed until the compression is good.

When the Engine Misfires.—This is occasionally caused by the use of a poor, or an unsuitable, grade of oil and either of which will form a film of carbon on the spark plugs.

When the Engine Hisses.—This may be caused by scored cylinder walls which in turn is often the result of a lack of oil; when this happens the cylinders will have to be rebored. Keep the lubricating system clean and you will save the engine and yourself much wear and tear.

When the Engine Smokes.—This is largely the result of (1) too much oil, or (2) oil that is not suited to the engine.

What to Lubricate the Clutch With.—*Oil Disk Type.*—Where the clutch is of the oil immersed disk type use a lubricant made of half kerosene and half lubricating oil; do not put more than a pint of the mixture in the case at one time and before putting in fresh oil drain off the used oil.

Cone Clutch Type.—When the clutch grips or takes hold suddenly lubricate the leather, if it needs it, with a little castor, or neatsfoot oil.

What to Lubricate the Transmission With.—The lubrication of the transmission gears comes next in importance to the engine. Now the teeth of gears are really little levers and two or three teeth on one gear pry the teeth on the other gear with a force equal to from 10 to 60 horse power.

With this tremendous frictional strain upon them the finest nickel steel gears would quickly wear away if some kind of a cushioning film did not separate the teeth as they press against each other. A good lubricant for the transmission must possess (a) lasting qualities, (b) resist great pressure and (c) slip easily in order to reduce friction to a minimum and at the same time cushion the pressure of the gears.

To satisfy the rigorous conditions exacted of a transmission lubricant a *gear compound* is generally used instead of oil. This is made by blending a *sponge,* or *fiber* grease with a good lubricating oil. This kind of a grease sticks well to the gears, forms a good cushion

for the gear teeth, makes the meshing practically noiseless and is far less likely to leak than an oil. Should the transmission case have a tendency to leak use a heavy grade of *stringy gear compound.*

What to Lubricate the Universal Joints With.—Almost as much pressure is brought to bear in a universal joint as there is in the transmission gears and unless a good lubricant of the right kind is used it is likely to run hot. Pack the joints with a liquid grease or heavy oil.

What to Lubricate the Differential With.—The differential gears are also subjected to tremendous leverages and hence they must have a lubricant that possesses all the wearing and slippery qualities of the best transmission compound.

It is good practice to use a heavier gear compound than that in the transmission because the teeth of the gears are larger and a greater cushioning surface between them is needed. A good gear compound of the heavier kind needs little attention, is economical and there is no danger of leakage.

What to Lubricate the Water Pump With.—The bearings of the pump should be lubricated with a *water-proof compound* so that a film will be formed which will not give way under the pressure of the water. You can buy a lubricating compound made especially for the purpose.

Your Lubricating Chart and Schedule.—I have not attempted to tell you which oil or what grease to use for the reason that each maker has given the lubrication of his car the greatest consideration and all the

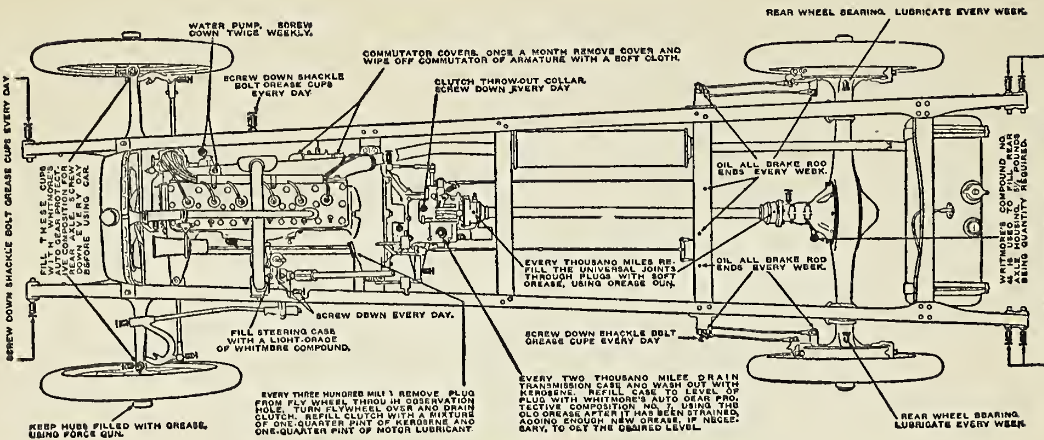


FIG. 56.—The lubricating chart of a Hudson Car.

different oils and greases that are on the market the severest tests.

Consequently he knows better than any one else the lubricants that are best suited to his machine. And whatever make of lubricants the car manufacturer tells you to use, use it and no others, no matter what the oil dealer or the garage man may say to the contrary.

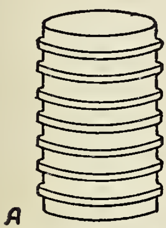
Further, when you buy a car you will get a *lubricating chart* with it, as shown in Fig. 56, only larger. This chart is a top view of the chassis which shows at a glance where (1) either oil or grease is to be used; (2) how much of the lubricant is to be used and (3) how often it is to be used. Make your lubricating chart instructions a fetish and your reward will be great in the days when your neighbor's car is in the scrap heap.

CHAPTER VIII

HOW THE COOLING SYSTEM WORKS

To keep the cylinders of the engine from getting too hot two general types of cooling systems are used and these are (1) *cooling with air,* and (2) *cooling with water.* A combination of these two systems is used on all cars with but two exceptions.

The Air Cooled Engine.—In this system the engine is so designed that the cylinders are cooled off by forcing a current of air directly on them.



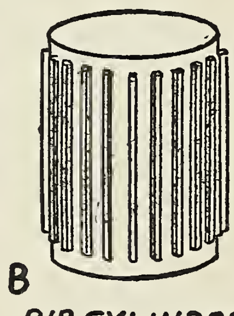


FIG. 57.—A. Air cooled cylinders. B. Air cooled cylinders.

To make the cylinders radiate the excess heat as rapidly as possible, parallel metal rings as shown at A in Fig. 57 or radial ribs as shown at B are cast on the outside cylinder walls. The stream of air is set up by a

fan, fixed to the rim of the flywheel as shown at C. The *Franklin* and the *Eagle-Maccomber* are the only cars using the air cooled type of engine.

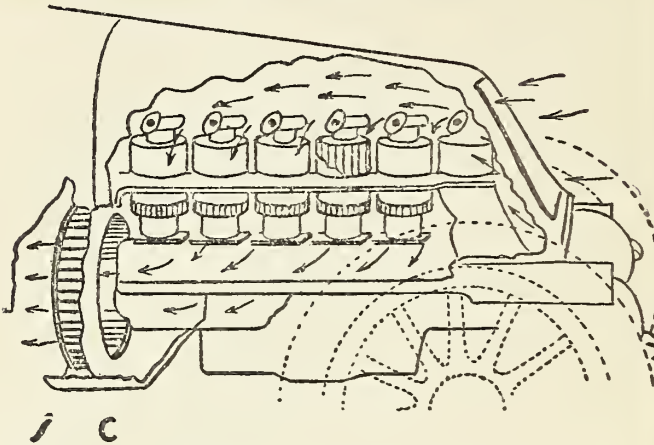


FIG. 57.—C. A Franklin air cooled engine. 2,220 cubic feet of air flows over the cylinders every minute.

The Water Cooled Engine.—The water cooling system may be divided into two classes and these are (a) the *thermo-syphon* system and (b) the *pump circulating* system.

In the water cooled engine the cylinders are *jacketed,* that is, each cylinder has another one cast around it, leaving a space between them, as explained in Chapter IV and shown at A in Fig. 32, and cold water is forced through this space around the cylinders either by the action of the heat itself or by means of a pump.

Whichever scheme is used the water is made to flow through a *radiator* usually set in front of the engine,

and this cools the water by the air striking it as the car runs along. The construction of the different kinds of radiators will be described presently.

The Thermo-Syphon System.—It is well known that when water is heated it rises to the top of the vessel and it follows, conversely, that the cold water will stay on the bottom, and this is the principle on which the *thermo-syphon* cooling system works. This is because cold water is heavier than hot water.

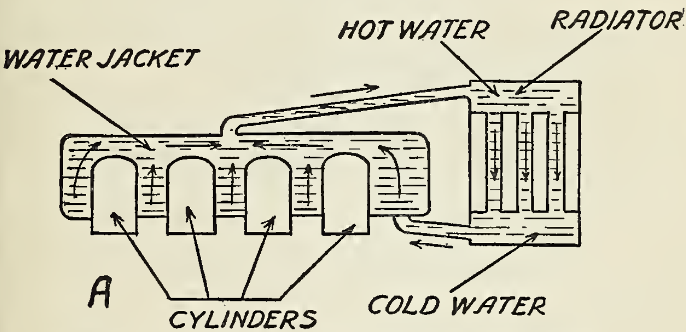


FIG. 58.—A. Diagram of the thermo-syphon system.

The jacketed cylinders are connected at the top and the bottom with the top and bottom of the radiator as shown at A in Fig. 58. When the cylinders heat the water enough it rises to the top and flows from the engine through the upper pipe to the radiator; now when the air strikes the radiator it cools the hot water at the top and this falls to the bottom when it flows through the lower pipe back into the jacketed cylinders again.

As the cold water flows into the cylinder jackets it pushes up on the hot water and the latter is forced

through the upper pipe to the radiator and so the circulation of the water around the cylinders is continuous. Over one third of the cars now made are equipped with the thermo-syphon cooling system. The system

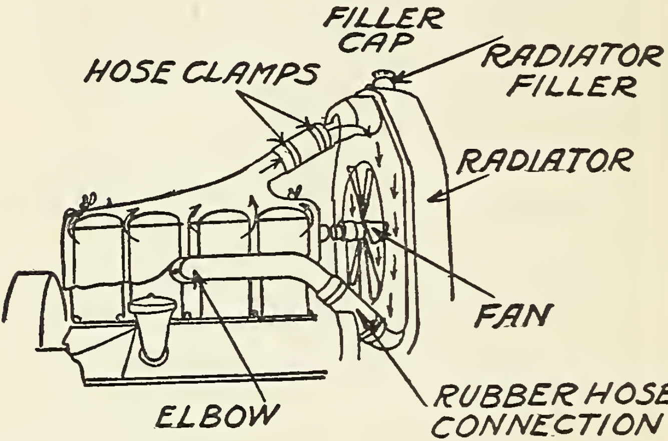


Fig. 58.—B. The thermo-syphon system on an Overland Car.

as applied to the *Overland* car is shown at B in Fig. 58.

The Pump Circulating System.—To make the water circulate around the cylinders without regard to the heat developed, a pump is used as shown at A in Fig. 59.

The pump is driven by a counter-shaft which is geared to the crank shaft; the pipe connected to the lower part of the radiator is coupled to the intake of the pump; the outlet of the pump is joined to the bottom of the cylinder jackets and the top of the latter is

connected in turn to the radiator. The pump system of a *Buick* car is shown at B in Fig. 59.

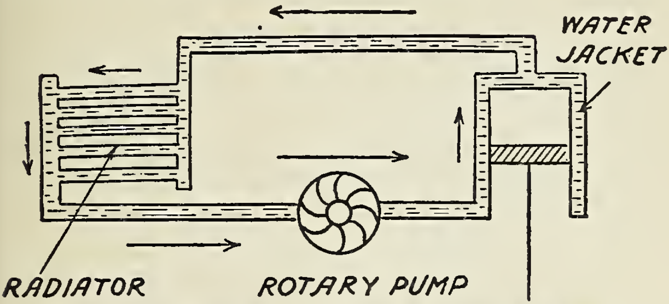


FIG. 59.—A. Diagram of a pump circulating system.

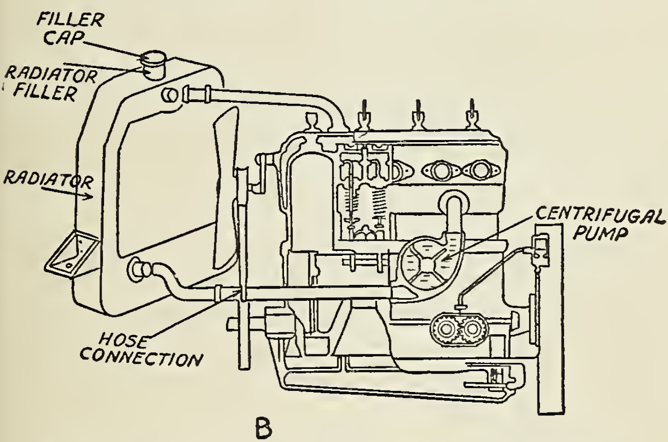


FIG. 59.—B. The pump circulating system on a Buick car.

Kinds of Water Pumps.—There are two types of pumps used for circulating water systems and these are (1) *centrifugal pumps* and (2) *positive,* or *force feed pumps.*

The Centrifugal Pumps.—There are various kinds of centrifugal pumps, but the cross-section of the one pictured in Fig. 59 shows the principle on which pumps of this kind work in general use on cars today. This simple and effective form of pump consists of a number of curved blades mounted like the spokes of a wheel on a hub and these fit snugly to the sides of the pump case and its circumference so that there will be as little leakage between the blades and the case as possible.

The water is led into the pump at or near the center of the case and it is thrown out by the centrifugal force of the blades, as they revolve, into the discharge pipe which is connected to the jackets.

Positive, or Force Feed Pumps.—There are two kinds of these pumps in general use and these are (1) the *gear,* or *tooth wheel pump,* and (2) the *rotary pump.* The first is made exactly like the oil pump shown in Fig. 54.

The second consists of an *eccentric* mounted on a shaft in a casing and when the eccentric revolves it presses against the circumference of the casing and in this way it forces a certain amount of water into the discharge pipe. These pumps are found usually on the higher priced cars.

How the Radiator Is Made.—The radiator is an arrangement made up of a large number of small pipes in or around which the water heated by the cylinders flows; and on or through which the air to cool it blows when the car is running.

There are many different radiators on the market

but all of them may be classified under two general heads, namely, (1) the *tubular radiator* and (2) the *cellular, or honeycomb radiator.* The radiator that has the largest surface exposed to the cooling action of the air gives the best results, but the cost, strength,

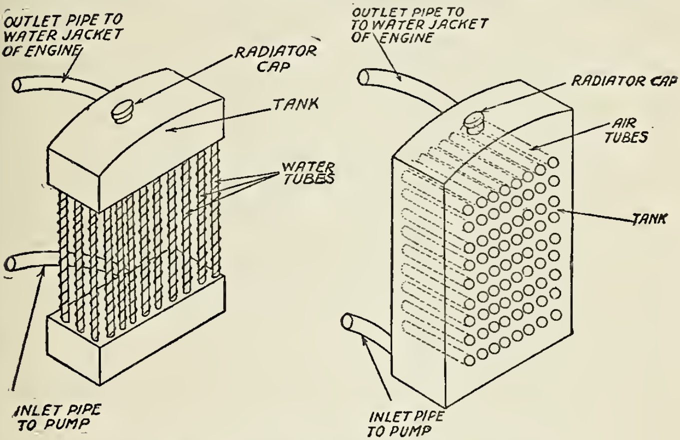


FIG. 60.—Tubular and cellular radiators.

weight, likelihood of leakage, and ease of repairing are also factors that must be taken care of in the design of radiators.

The Tubular Radiator.—In this type a large number of parallel tubes, which are open at both ends, are soldered to the top and to the bottom of the radiator as shown at A in Fig. 60. In some radiators the tubes are set vertically, and in others they are set horizontally, the former way, though, being the most common.

Then parallel disks or spirals of sheet metal are soldered on each tube about 1/8 of an inch apart and as the

water flows through and heats the tubes the heat is radiated by them and therefore the tubes and the water in them are cooled by the air striking the disks or spirals.

The Cellular Radiator.—This type of radiator is made up of a large number of small short tubes set parallel with each other and horizontally; hence these tubes are only as long as the thickness of the radiator and are soldered to a front and back plate drilled full of holes as shown at B in Fig. 60.

When water is poured into this radiator it fills the spaces *between* the tubes and the air blowing *through* the latter cools the water circulating around them. A cellular radiator is less likely to be damaged than a tubular radiator and it is much easier to repair, especially if you are on the road.

The Combination Fan and Water Cooling System.—In addition to the radiator cooling system a fan is used to augment the circulation of the air on nearly all cars.

The fan is usually set just back of the radiator and it aids materially in sucking the air through it and this cools the water much more rapidly. The fan is often mounted on an adjustable arm the lower end of which is fixed to the block of the engine by means of a stud. The common practice is to drive the fan by a belt from a pulley on the end of the driving shaft. It can also be driven by direct gearing or by a silent chain.

Keeping the Cooling System in Good Order.—*The Radiator.*—(1) Fill the radiator with clean water,

pouring it through a strainer, and keep it full. Use soft water as hard water generally contains lime and other impurities. (2) When the radiator is empty, or nearly so, do not pour cold water into it.

(3) Drain off the water in the cooling system at least once a month by opening the drain cock, or plug, at the bottom of the radiator, and fill it with clean water; (4) when dirt is allowed to accumulate on the outside of the tubes of a tubular radiator or inside of the tubes of a cellular radiator it forms a film on them that keeps the heat from being radiated and this may cause the engine to overheat; always keep the outside of the radiator washed clean.

(5) To thoroughly clean the radiator inside, uncouple the hose connections and flush it out by means of a garden hose connected with a hydrant so that the water under pressure will flow from the bottom through to the top; this will remove all rust and scale that may have accumulated inside and this must be done every three months to make the cooling system effective; finally don't use a potash solution to clean the water cooling system; instead dissolve one pound of *sal soda* in a gallon of water; fill the cooling system with it, let the engine run an hour and then drain it off while the motor is still warm.

Adjusting the Fan.—The belt should be kept tight enough to prevent it from slipping on the fan pulley, but it should not be too tight. The right adjustment can be made by moving the arm that carries the fan and tightening up the bolt that holds it to the engine block.

Taking Care of the Pump.—On each side of the pump on the shaft you will find a grease cup and this should be given a turn occasionally. Should the pump begin to leak around the shaft screw up the *stuffing box* but not too tight or the shaft will bind.

What to Do When Winter Comes.—If a car is not properly taken care of in cold weather very serious damage may result.

When you put your car in the garage if the temperature is 40 degrees above 0 *Fahrenheit* or less, draw off the water in the cooling system, for if the temperature should drop to 32 degrees F., the water will freeze in it and this may put holes in the radiator tubes and even crack the cylinders.

When you stop your car in cold weather don't let the engine stop, but throttle it down to keep the water warm.

If the radiator is fitted with *ventilating doors,* close them; if not, then cover about half of the lower part of it with tin or cardboard.

When Zero Weather Sets In.—When the temperature drops to the freezing point draw the water from the circulating system and fill it with one of the following *anti-freezing solutions:*

For Temperatures from 32° to 15° Above 0° Use

Wood Alcohol	15 per cent
Glycerine	10 per cent
Water	75 per cent
	100 per cent

For Temperatures from 15° Above to 0° Use

Wood Alcohol	20 per cent
Glycerine	15 per cent
Water	65 per cent
	100 per cent

For Temperatures from 0° to 10° Below 0° Use

Wood Alcohol	25 per cent
Glycerine	15 per cent
Water	60 per cent
	100 per cent

For Temperatures from 10° to 20° Below 0° Use

Wood Alcohol	50 per cent
Glycerine	25 per cent
Water	25 per cent
	100 per cent

Add enough alcohol to make up for the amount that evaporates.

CHAPTER IX

HOW THE LIGHTING AND STARTING SYSTEMS WORK

Every passenger car now made is equipped with *electric lights* and, with but very few exceptions, with *electric starters.*

Now in order to have electric lights as well as to start the engine without cranking it by hand a *storage battery* is needed, and this being the case the most natural thing in the world was to make it also serve as the initial source of current for the ignition system as described in Chapter VI, and this is what is meant by the *three-in-one* system.

The Electric Lighting System.—There are three chief parts to the lighting system of whatever make, and these are (1) the *storage battery,* (2) the *dynamo* to charge it with and (3) the *automatic cut-out.*

The Storage Battery.—*How the Battery Is Charged.*—Each *cell* of a storage battery will develop a *pressure* of about 2 volts and the amount of the current, or *amperes,* delivered by it depends entirely on the size of the plates. About 90 per cent of the cars now made are fitted with a 6 volt battery, 8 per cent have a 12 volt battery and the others have a 24 volt battery.

The battery is charged by means of a small *dynamo* geared, or belted, to the crank shaft of the engine. Now

when the pressure, or voltage, of the dynamo when running at full speed, is greater than that of the storage battery some of the current will flow into the latter and charge it. But should the dynamo fall off in speed, and hence in voltage, the current from the storage battery will flow back through the coils of the dynamo unless the circuit is broken.

To automatically *close* the battery circuit when the dynamo is delivering its full voltage, and to *open* the circuit when the voltage is less than that of the battery, an *automatic cut-out,* or switch, is provided and this is what is meant by the terms *floating a storage battery on the line* and *floating on the line principle.*

Testing the Battery.—There are three simple ways to test a storage battery and these are with (1) a *test-lamp;* (2) a *voltmeter* and (3) a *hydrometer.* To use a test lamp, see A, Fig. 61. Hold one end of the lamp wires on the positive battery terminal and the end of the other wire on the negative terminal and if the battery is all right the lamp will light. Each cell should be tried out separately if the lamp does not light when the whole battery is tested.

To test the battery with a *voltmeter,* see B; hold the ends of the wires on the + and — terminals of each cell of the battery, and if it is in working order the voltmeter will show about 2 volts. A hydrometer, see C, is an instrument which is floated in the battery solution, or *electrolyte,* and the depth to which it sinks shows the *specific gravity* of it. The solution of a fully charged battery in good condition will generally have a specific gravity of between 1.275 and 1.300, and the cells of

a battery should not vary more than 15 or 20 points.

The Dynamo.—*How it is Made.*—A dynamo is made like the low tension magneto described in Chapter VI, but instead of having permanent magnets a soft

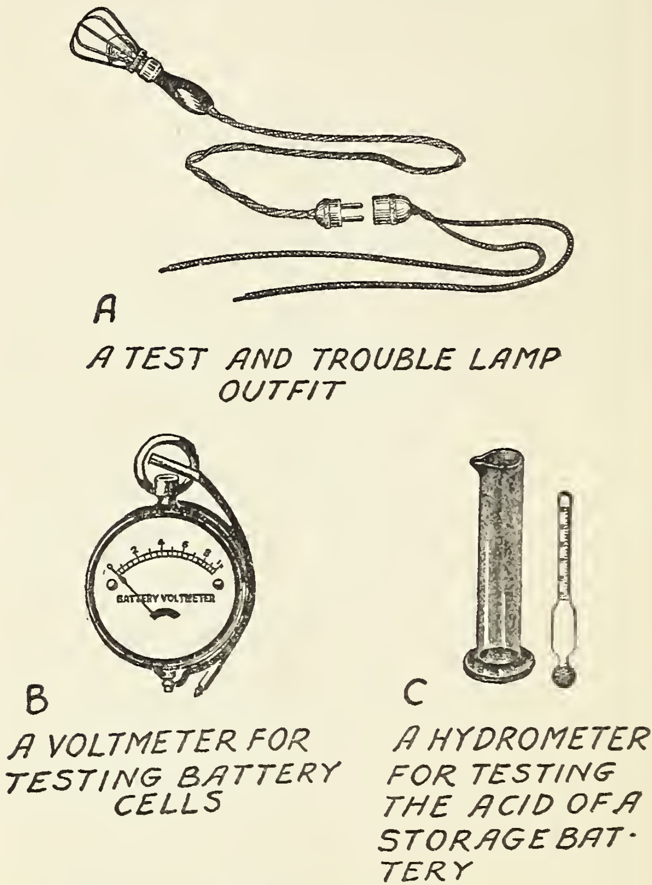


Fig. 61.—A, B and C. Apparatus to test the storage battery.

iron core wound full of wire is used; when a current flows through the coils of wire the iron core, or *field magnet* as it is called, becomes strongly magnetic.

The field magnet of a dynamo can be wound in three different ways, and these are (1) *series wound,* as shown at A in Fig. 62; (2) *shunt wound* as at B, and (3) *compound wound* as at C. Now the voltage and the current

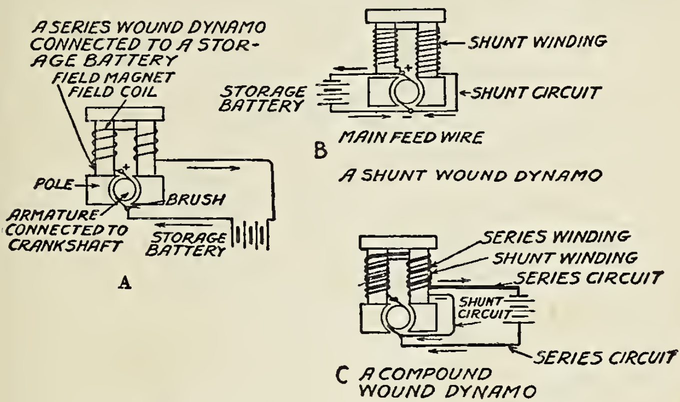


FIG. 62.—A, B and C. How dynamos are wound.

(amperes) of a series wound dynamo *decrease* as the *load* of the outside circuit—that is, the power taken by the lights or the storage battery—is *increased.*

The voltage of a shunt wound dynamo *increases* as the current in the outside circuit *decreases* and the other way about, and so if a dynamo has both a series and a shunt wound field magnet, namely, a compound winding, it will give a more nearly constant voltage at all loads, and this is the kind of a dynamo that is used for motor car work.

The Automatic Cut-Out.—An easy way to close a circuit with an electric current is to use an *electromagnet.*

An electromagnet consists of a bar of soft iron on which is wound a coil of copper wire. If a current is made to flow through the coil and a flat piece of soft iron, called an *armature,* is brought near the end of the electromagnet it will be attracted to it.

How the Cut-Out Works.—If now the electromagnet is made to close a pair of spring contact points, just as it does in the vibrator of a spark coil, and the contact points are connected in one of the main line wires between the dynamo and the storage battery as shown at A in Fig. 63, while the coil of the electromagnet is connected across the main wires between the dynamo and the storage battery, it is clear that when the dynamo begins to develop current it will energize the electromagnet; this in turn will attract the armature and so close the main line circuit when the current from the dynamo will flow into and charge the battery.

But when the dynamo slows down the current gets weak in the coil of the electromagnet, the spring flies back and opens the contacts and the dynamo is automatically cut out from the storage battery.

Because the current in the electromagnet is apt to get weak momentarily even when the dynamo is running fairly fast a second coil is wound around the first coil on the electromagnet and this is connected in the positive main line, or feed wire, as shown at B. As soon as the contact points are closed by the current flowing

through the first, or *shunt* coil as it is called, of the magnet the current begins to flow through the second, or *series* coil, and this strengthens the electromagnet and so prevents the contact points from breaking apart, unless the speed of the dynamo falls too far below the normal.

How the Output of the Dynamo Is Regulated.—Besides the cut-out above described there is another pair of

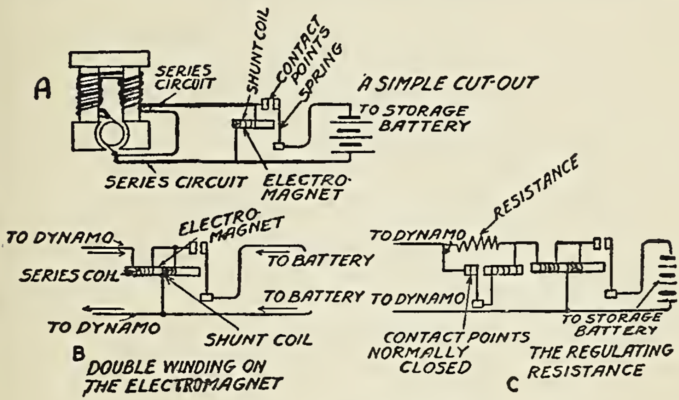


FIG. 63.—A, B and C. The automatic cut-out.

contact points, called the *regulator points,* which are opened and closed by another electromagnet connected in circuit with the field wires as shown at C. When the points are drawn apart a *resistance* is cut into the field circuit and as the current must then flow through the resistance it prevents a further increase in the output of the dynamo.

How the Current Is Measured.—To know to what extent the battery is charged, how much current it

is delivering and whether the system is working properly, an *ammeter,* see A, Fig. 64, is used.

The ammeter measures the amount of current in *am-*

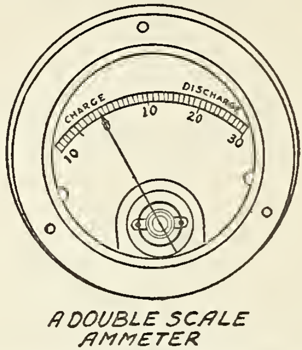


FIG. 64.—A. A double scale ammeter.

peres and it is connected in the circuit as shown in Fig. 65, that is, in the negative feed wire between the dynamo and the storage battery. It usually has a double

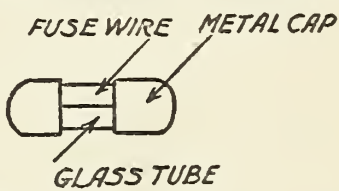


FIG. 64.—B. A fuse is an electric safety valve.

scale, one side being marked *charge* and the other side *discharge.*

When the needle is at rest on 0 it shows that the battery is not receiving any current and that it is not delivering any current. When the needle swings over

to the side marked *charge* it shows the actual amount of current that is generated by the dynamo and which is either charging the battery or is being used for lighting and ignition purposes. When the needle swings over the side of the scale marked *discharge* it shows the amount of the current that is being pulled by the lamps and the ignition system.

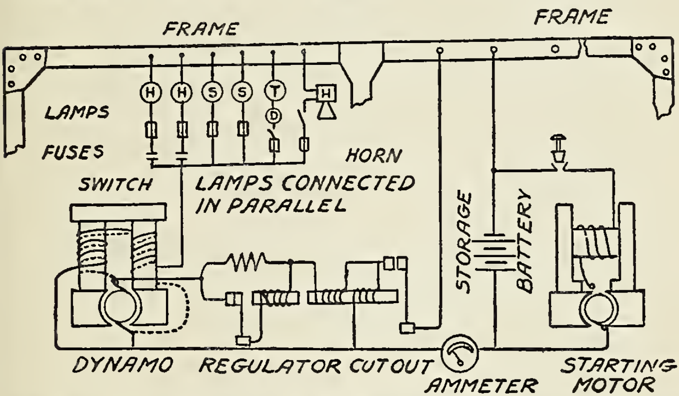


Fig. 65.—Wiring diagram of a lighting and starting system complete (Gray and Davis system).

How the Lamps Are Wired Up.—While it amounts to exactly the same thing in the end there are two systems used for wiring cars and these are (1) the *one-wire* system and (2) the *two-wire* system.

In the one-wire system a single wire is run from the battery to the lamps and the return connection is made through the frame of the car as shown in the wiring diagram Fig. 65; this is called also the *grounded* system. In the two-wire system the return connector is an insulated wire.

Why Lamps Are Connected in Parallel.—The lamps are connected up in *parallel,* that is, they are connected across the field wires, as shown in Fig. 65. The reason this is done is because the voltage which each lamp takes is just about that which the battery can develop and each one *pulls* just the amount of current, or amperes, it needs to light it. Then again if one lamp burns out it does not affect the others as it would if they were connected in *series.* The dash and the tail lamps, though, are usually connected in series so that if the tail lamp burns out the dash lamp will also go out and so indicate it.

Lamps Have Two Sources of Current.—When the car is running over 10 miles an hour the lamps are fed directly by the current generated by the dynamo and when the car is running less than 10 miles an hour the lamps are fed by the battery.

How the Lamps Are Protected.—To protect the lamps from burning out a *fuse,* see B Fig. 64, is connected in circuit between each lamp and the one next to it and the positive feed wire. For this reason all of the wires of all of the parts are led to a *junction box* fixed in some accessible place.

The Sizes of Wires to Use.—Use *standard automobile wire* or *cable* of the following sizes: For wires connecting the dynamo to the battery and to the junction box use No. 10 wire Brown and Sharp gauge. For junction box to head lamps use No. 12 B. and S. gauge. For all other lamps and horn use No. 14 B. and S. gauge.

How the Horn Is Wired Up.—The magnet, or motor,

which operates the horn is wound for the same voltage as the lamps and it is also connected in parallel with them as shown in Fig. 65.

The Electric Starting System.—All sorts of schemes have been devised to start the engine without having to crank it by hand and these may be sifted down into four general types, namely, (1) *compressed air;* (2) *gas;* (3) *mechanical,* and (4) *electrical.*

Compressed air and gas starters are entirely out of use and so need no description. As far as I know, and I have examined the specifications of 159 passenger cars, the Ford is the only one that is not equipped with an electric starter; there are several mechanical starters on the market for Ford cars, but as space is at a premium, let's stick to the more general electric starter.

The Electric Motor.—Away back in the early days of electric lighting when the dynamo was as frisky as a short tailed calf in fly time, some one accidentally found that when an electric current was made to flow into the coils of a dynamo the armature would revolve and so the electric motor came into being just like Topsy.

The Electric Starter.—Now all there is to an electric starting system is the motor and the storage battery with a starting switch in the circuit between them as shown in the wiring diagrams, Figs. 65 and 66; whenever the switch is closed the current will flow through the coils of the field magnet, the armature will revolve and so develop power.

How the Drive Is Made.—The main thing to know about an electric starter is (1) how the electric

motor is connected with the engine so that it will start it, and (2) how after starting the engine it is disconnected from it.

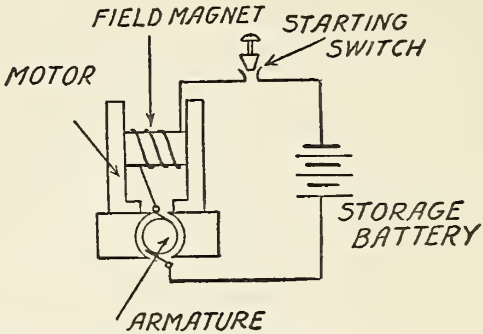


FIG. 66.—Wiring diagram of an electric starter.

One way it is done is like this: The flywheel of the engine has teeth cut on its rim, making it a gear as shown at A in Fig. 67. A small gear is fixed to the

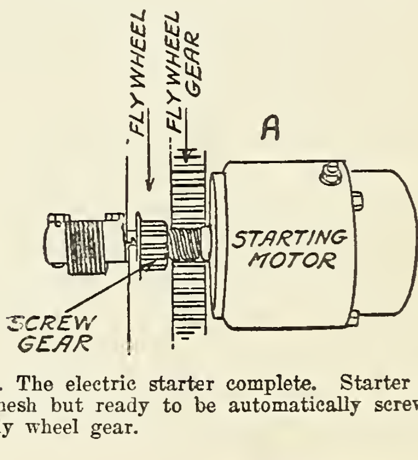


FIG. 67.—A. The electric starter complete. Starter gear out of mesh but ready to be automatically screwed into the fly wheel gear.

shaft of the motor so that it will mesh with the flywheel gear in order to start the engine and to demesh automatically after the engine has started.

Look at B and everything will be clear. A sleeve with screw threads cut in it is mounted on the shaft of the armature; a small gear weighted on one side and which has threads cut on the inside of it screws on

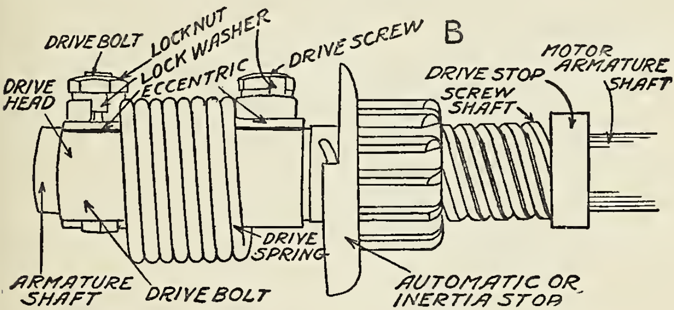


Fig. 67.—B. The motor drive of an electric starter.

the sleeve like a nut on a bolt. The sleeve is secured to the armature shaft by means of a strong stiff spring, one end of which is fastened to the shaft with a bolt and the other end is fastened to the screw sleeve with a screw.

How the Drive Works.—Suppose now the engine is stopped and you want to start it; the gear on the sleeve of the armature shaft is demeshed from the flywheel gear as shown at A. Now when you press down on the starting switch it closes the battery and motor circuit and the armature shaft begins to spin; the *inertia* weight of the small screw gear keeps it from re-

volving with the shaft with the result that it screws its way along the threaded sleeve until it meshes with the gear on the flywheel.

When the screw gear reaches the stop collar it must, of course, turn with the sleeve; by this time the electric motor will have reached its highest speed and, hence, is developing its greatest power, and as the screw gear is smaller than the flywheel gear in about the ratio of 1 to 10 it exerts a tremendous leverage and so turns the crank shaft around with it.

The purpose of the spring connecting the sleeve to the shaft is so that the strain on the armature shaft will be eased up a bit; the teeth are beveled and this with the cushioning effect of the spring lessens the chances of the teeth of the screw gear being stripped or the shaft sheared off.

When the engine has been started and the speed of the flywheel is high enough it makes the screw gear revolve faster than the threaded sleeve; this causes it to move endwise out of mesh and in this way the engine is prevented from driving the electric motor. Thus the screw gear is demeshed automatically from the flywheel gear and being weighted it is held to the sleeve in this position until the switch is opened and the electric motor stops.

The above device is the Eclipse-Bendix drive and is largely used for both passenger cars and motor trucks. Various other means for meshing and demeshing the starting motor and flywheel gear have been devised, but the one described will serve to show the fundamental principles underlying electric starters in general.

CHAPTER X

WHAT YOU CAN FIX ON YOUR CAR

There are some things you can fix on your car when it goes wrong and others you had better let a machinist attend to.

It's pretty hard to draw the line between the things which you can set to rights and those which are a mechanic's job, but I am assuming that you are the average motor car owner and that the mechanism is new to you. So let's hop to it.

When Your Car Stops on the Road

Finding the Trouble.—If there is nothing broken on your car the trouble must be with the engine. Look for the cause as follows:

(1) See that there is a supply of gasoline in the tank.

(2) That there is plenty of lubricating oil, and

(3) That there is enough water.

Finding there is a full complement of these liquids, the trouble then must be either:

(1) In the fuel system, or

(2) In the ignition system.

See if the gasoline pipe line is clear by flooding the carburetor and if it is, then you are reasonably sure the fault is with the ignition system. In this case see that:

(1) The switch is on;
(2) The battery is not run down;
(3) The connections are tight;
(4) The wires are not broken;
(5) The vibrators of the spark coil are not stuck;
(6) The contacts in the timer are clean;
(7) The spark plugs are not broken, and
(8) That there is a strong enough spark.

When you have attended to these few several little things, crank your car and go ahead.

The Things You Ought to Carry.—*The Tools You Should Have.*—The following kit of tools, see Fig. 68, will be found useful in making road repairs: (1) a machinist's hammer; (2) large and small screw drivers; (3) a 6-inch and a 12-inch monkey wrench; (4) a cold chisel; (5) a couple of flat mill files; (6) a key puller; (7) a pair of 6-inch combination pliers; (8) a pair of long nose pliers; (9) several open end wrenches; (10) one tire repair outfit; (11) a wrench for spark plugs; (12) a wrench for hub caps; (13) a wrench for valve caps, and (14) an offset screw driver.

The Implements You Need.—(*A*) A jack; (*B*) an air pump for inflating tires; (*C*) a grease gun; (*D*) an inspection lamp; (*E*) a tire caliper; (*F*) a starting handle, and (*G*) a set of tire applying levers, or irons.

Supplies That Come in Handy.—(a) Extra fuses; (b) an ignition resistance; (c) a fan belt; (d) a canvas, or rubber pail; (e) hose for the air pump; (f) a can of lubricating oil; (g) a can of cup grease; (h) batteries; (i) insulated wire; (j) spark plugs; (k) valve springs; (l) cotton waste; (m) one extra casing in a

tire cover and (n) two or three inner tubes well wrapped and put in a box for protection.

How to Repair a Tire While You Wait.—Be sure to include in your tire repair outfit (1) a box of

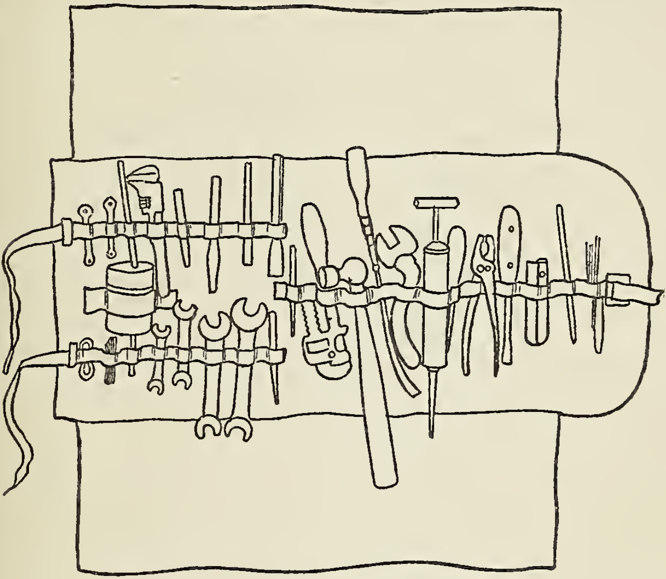


FIG. 68.—The kit of tools you need.

permanent puncture plugs and (2) either a box of *cementless patches* or Goodrich *self-vulcanizing patches.*

Repairing an Inner Tube.—For Nail Hole Punctures.—A small puncture such as a nail hole can be quickly and easily fixed by using a puncture plug as shown at A in Fig. 69; push the plug into it and it will seal up tight without the use of cement.

For Small Cuts and Punctures.—Where there are

small cuts or punctures too large to be plugged, then use a self-vulcanizing or cementless patch as shown at B. To put either kind on, scour the tube off with a bit of waste dipped in gasoline all around the hole for a couple of inches.

Rub the cleaned surface with emery cloth to roughen

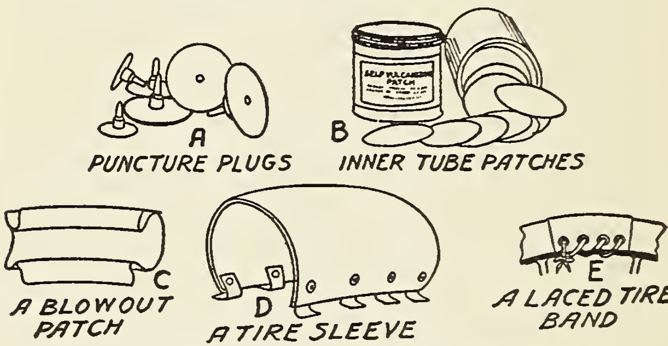


Fig. 69.—Quick repairs for the road.

it and clean again with gasoline; now pull the muslin from the patch and rub the surface of it with a bit of waste soaked in gasoline; this done, press the patch flat on the tube over the puncture and put it in the *casing*. If it is a self-vulcanizing patch the heat developed by running will vulcanize it.

For Larger Cuts and Punctures.—The Goodrich tire people sell what they call a *clinch patching outfit* and where the cuts and holes are too large or ragged to be repaired by an ordinary patch you can fix it with far less trouble and in much less time with this outfit than if you carried a portable vulcanizing set with you.

Repairing a Cut in a Casing.—If the casing is cut or has a gash in it, clean the dirt out with a stiff brush and wash it clean with gasoline; next roll up a bit of *plastic*[1] and force it into the cut until it is even with the casing. If the hole is a large one put on a thin coat of cement first and then force in the plastic.

Repairing a Blown Out Casing.—If the blowout is not large use a *blowout patch* as shown at C; this is made of duck molded to the shape of the tire and is put on inside of the casing and between it and the inner tube.

The *tire sleeve* is made of rubber and fabric and this fits over the outside of the casing and is held fast by hooks under the bead, or rim; it is shown at D. *Tire bands* are made of leather or rubber and these are laced on over the casing as shown at E. Should any great injury happen to either your inner tubes or casings, have them vulcanized by some reputable repairer.

Fixing the Radiator.—*A Stuck Radiator Cap.*—This is often caused by the heat of the radiator expanding the ring on which the cap screws. Soak a piece of waste in cold water and hold it on the ring until it cools off, being careful that the cap is not cooled off by it.

Stopping Up a Leak.—If the leak is small it can be plugged up with chewing gum, but if it is of considerable size put a cork in it, that is, if the holes are getatable; solder the holes up as soon as you reach your garage. There are lots of *fillers* on the market, but it is

[1] "Plastic" is the trade name of a tire filler and it can be bought at any supply store.

poor practice to put anything into the radiator for this purpose.

Leaks in the Gasoline Pipe.—If the leak is small it can be stopped by plugging up the hole with a bit of common brown soap, and then wrap a piece of electrician's tape around it to hold it in place. Another way is to cut a strip of inner tube about two inches wide and three inches long, wrap it around the break and wind a layer of soft iron or copper wire around it.

When the Water Pump Leaks.—If the leak is at the joint where the flanges are bolted together it shows that the gasket has rotted away; tighten up the bolts and if this doesn't stop it drive a thin, sharp-pointed stick into it, then when you get home put in a new gasket.

Putting on a New Fan Belt.—A fan belt is liable to break any time. In putting on a new belt the best way is to rivet the ends together; a laced belt is almost sure to pull apart unless it is done by a man who knows the trick of it.

Fixing Spark Plug Troubles.—*Leak Around the Spark Plug.*—If a spark plug is not in tight enough the leak will cause a loss in compression. You can tell if there is a leak by squirting some oil on the plug around the threads when the leak will cause it to bubble. If the leak is a bad one the escaping gas will make a hissing noise. Screw up the offending plug and if it still leaks it shows that the threads are worn and the way to fix it is to put in a new one.

To Clean a Spark Plug.—Scour the points with a toothbrush dipped in gasoline. If the soot is heavy,

scrape the points off with a knife blade, or a spark-plug cleaner, and wash them out with alcohol or gasoline. If the deposit is very heavy use a jeweler's file and file off the opposing points until they are bright.

To Loosen Screws and Nuts.—When a screw is hard to loosen screw a monkey wrench to the flat blade of a screw driver as shown at A in Fig. 70; hold it

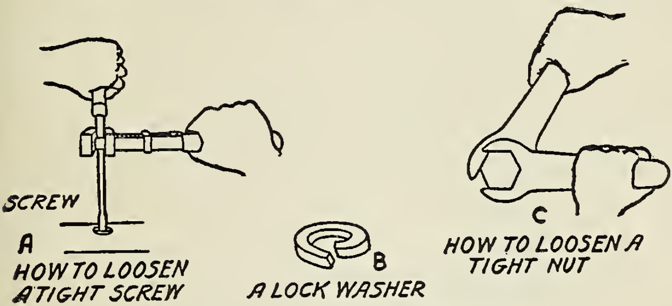


Fig. 70.—A couple of good kinks.

down hard with your left hand and turn the wrench with your right. This will give you the extra leverage you need. Always use the largest screw driver the screw will take.

A nut that is stuck can be loosened if it is possible to heat it a little; if not, put two thin wrenches on it as shown at C and the extra leverage will usually be enough to loosen it.

How to Make Nuts Hold Tight.—A nut that has a tendency to work loose and come off can be made to hold by putting on a *lock washer,* as shown at B, that is, a a spring washer under it, and then screwing it up tight; another way is to screw a second nut on top of the first

one. To absolutely prevent a screw or bolt from loosening it is possible, in some places, to bore a hole in the end of it and put a *cotter pin* in it.

When the Clutch Acts Up.—*A Clutch That Slips.*—When you have trouble with a cone clutch that slips it is because the leather on it is oil soaked. This may be remedied temporarily by washing off the leather with gasoline and then rubbing some *fuller's earth* well into it.

A Clutch That Binds.—A *fierce clutch,* as it is called, is caused by the leather becoming too dry; it can be eased up by rubbing castor or neatsfoot oil on it. To properly fix the clutch the adjusting nuts on the inside of the cone should be screwed in or out as the case may require.

What Not to Do.—Don't keep on running along when you hear a strange noise about the car, but stop and find out exactly what causes it. Then fix it right there; run into the nearest garage or beat it back home as the exigencies of the case may demand.

When Your Car Is in the Garage

When the Valves Need Grinding.—*How to Test the Compression.*—Unless the valve heads are made of *tungsten steel* the heat of the engine will warp them and this makes the valves leak, when of course the compression will be poor.

A more common cause of poor compression is the carbon deposit which collects on the valve seat, and this in turn is due to using too rich a fuel mixture, or too much

oil, or too poor a grade of the latter. When the loss of compression is due to any of these causes, it is time to *grind the valves.*

To know when this is really needed, crank the engine slowly by hand and you can easily *feel* if there is a piston that works with too little resistance on the compression strokes and also which cylinder it is in.

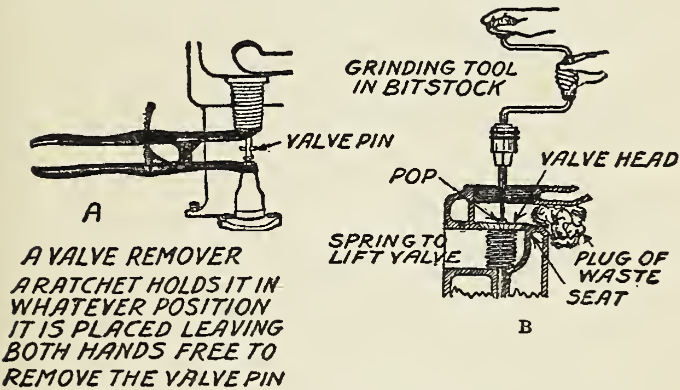


FIG. 71.—A and B. How to take out and grind a valve.

How to Take Out the Valves.—The first thing to do is to (a) drain off the water from the cooling system; (b) take off the cylinder head; do not disturb the wiring and lay it in a clean place; (c) then take off the valve covers; (d) take out the valve by using a *valve lifter* tool, see A Fig. 71, and (f) put a plug of waste in the port between the valve and the cylinder as shown at B in Fig. 71, to keep the abrasive from falling inside and cutting the piston and cylinder.

How to Grind the Valves.—Get or make a grinding

paste of fine emery, No. 120, or ground glass, and oil —you can buy it ready made—and thin a little of it down with a few drops of kerosene and lubricating oil.

Rub the mixture on the bevel edge of the valve seat with your finger, then set the valve head in the seat and turn it around to and fro with a *grinding tool* set in the chuck of an ordinary brace as shown at B, with just enough pressure to hold the valve in the seat.

Lift the valve from its seat from time to time so that the abrasive will be equally distributed over the beveled edges, and do not turn the valve more than a quarter way around at a time or you will be very apt to scratch the edge of the valve seat. Don't forget to take out the waste when you are through.

How to Tell When a Valve Is Seated Right.—To tell when the valve you are grinding seats properly, wipe the abrasive off clean and mark the beveled edge with a soft lead pencil as shown at A in Fig. 72. Now seat the valve and turn it back and forth; if all the pencil marks are rubbed off you will know the valve fits the seat perfectly; if not, continue the grinding operation. This is a far better test than to use Prussian blue.

Stretching and Replacing Valve Springs.—When a valve spring is weak, especially if it is an exhaust valve spring, the engine will not run with its accustomed smoothness; this is caused by a part of the compressed fuel charge escaping, which of course weakens the effect of the explosion.

To detect a weak valve spring put the blade of a screw driver between the coils of the spring while the engine

is running. If the engine runs faster or smoother it shows that the spring is weak and needs stretching or, better, a new one.

To stretch a spring remove it from the valve stem,

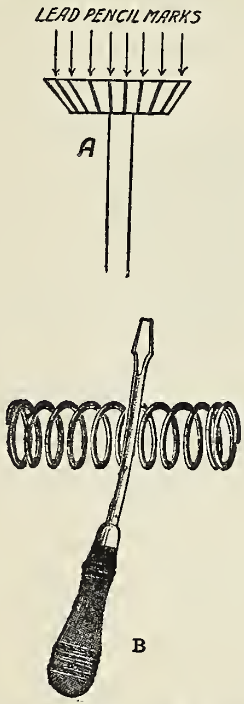


FIG. 72.—A. Testing the seating of a valve. B. Stretching a valve spring.

put the blade of a large screw driver between the first two coils at one end and turn the screw driver on it just as you would a nut on a screw as shown at B.

This will stretch all parts of the spring equally.

To Remove Carbon from the Cylinders.—You can tell when there is carbon in the cylinders by the engine backfiring, by knocking and by a lack of power when taking a hill on high gear.

To remove the carbon deposit take off the cylinder head and take out the inlet and the exhaust valve caps;

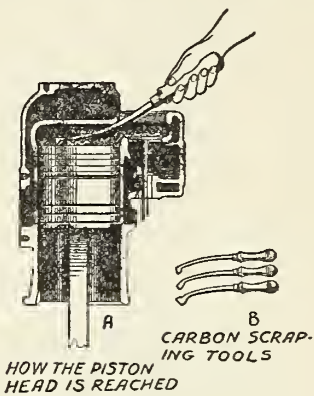


Fig. 73.—Scraping out the carbon.

now turn the crank shaft over until the pistons you want to clean are at their top dead centers when you can reach the heads of the pistons as shown in Fig. 73. You can buy scraping tools especially formed to enable you to get at the piston heads and cylinder walls in the easiest way.

When all of the carbon is scraped loose turn the crank shaft until the exhaust valve of the cylinder you are working on lifts and then scrape the carbon into the exhaust passage; now when the engine is started the carbon will be forced out by the exhaust gases. To be

sure that none of the loose carbon sticks between the valve head and its seat, brush them carefully and wash clean with kerosene.

Putting in New Piston Rings.—To take off worn piston rings easily you can get a tool made for the purpose, or a pointed tool can be used to lift the end of the ring from the groove.

Two kinds of piston rings are used and these are (1) cast iron rings and (2) soft steel rings. An iron ring can be expanded and then slipped over the head of the piston into its groove or seat. To insert a steel ring lay it on the head of the piston and press down on one end until it slips into the groove, but do not expand it; this done, work the ring around as though you were screwing it into the groove.

If it is to go into the second or third groove, thread the end into the next groove and screw it around as before. In putting on the rings be mighty careful not to dent or kink them.

How to Adjust the Brakes.—If the brake rods get out of adjustment the brake hands and the drums may make contact with each other; this causes the brakes to drag and hence there is a loss of power.

Always adjust the brakes on the road so that they will pull equally on both sides, for if the brake on one side or the other drags, the car will have a tendency to skid. The brakes can be tightened up by means of turnbuckles on the brake pull rods, and they can be adjusted by means of nuts at the after ends of the brake rods.

How to Make Good Gaskets.—A *gasket* is a thin, flat ring or other shaped piece of packing made of

rubber, leather or other material and this is placed between two flanges which are bolted together to make a water- or a gas-tight joint.

Gaskets made of ordinary rubber packing are of little service in gasoline engine construction, for hot water rots and the hot gases burn them away. It is better to use *asbestos packing* which has a brass or bronze wire mesh.

After marking out the shape of the gasket needed on the asbestos packing, using either the flange itself or a paper *template* for a pattern, you can go ahead and cut it out with a cold chisel and a hammer.

Replacing Broken Parts.—Every motor car company issues a *Price List of Parts,* and you should have one of these lists so that immediately a part is broken on your car you can find the correct name, the number and the cost of it, and you can send direct to the factory for it if you want to.

You will be able to make almost any small replacement yourself, but if it is some large part that is broken, you can let the machinist send for it and, knowing the price, he can't overcharge you, at least for the material.

CHAPTER XI

WHEN YOU NEED A MACHINIST

Again taking it for granted that you are like the great majority of motorists in that you are not a natural born mechanic and further that you have neither the time, the inclination nor the equipment to make a repair of the more difficult kind, the next best thing to know is when you really need a machinist.

When You Have a Breakdown on the Road.—Should some part actually break when you are on the road and your car lie down on you—though you may be on top of it—don't give up the *bumboat,* for where there's life there are a lot of *alternatives* (correct, according to John Stuart Mill and Gladstone).

And here are a few of them: (1) wait for a passing driver, or a *chauffeur,* to help you out; (2) telephone to the nearest sales agent who handles your make of car and have him send his service man to you; (3) walk to the nearest garage and get a *trouble shooter* to go back with you, and (4) drink an auto cocktail, i. e., a glass of gasoline with a dash of oil and a nut in it and it will put enough *pep* in you so that you'll think you're going home at a speed of 50 miles an hour.

Now if you let every willing man-at-the-wheel that comes along tinker with your car it won't cost you anything, but it won't be worth a tinker's dam either when

they get through with it; on the other hand, if you send for an expert you must expect to pay Charlie Chaplin's price for the service rendered, and, finally, if you follow the last horrible example you'll never get to the office next morning in time to open the mail. The answer is, know to a dead certainty that you can't fix your car yourself before you call in outside help.

After Your Car Is in the Shop.—About 60 cents an hour is the rate usually charged at a garage machine shop for the time of a skilled mechanic while he is working on your car.

And this would not be half-bad if he worked *all of the time* on your car that you are charged up with, but instead he helps Bill tighten a nut on that dinky roadster next to him and shows Jim how to set the timing gears on that big *berlin* over there.

Besides, he has to answer a couple of dozen questions which everyone asks him from the boss on down to the washer and when he hasn't anything else to do he spins a yarn or two just to pass the time away—your time—and the time stamp ticks merrily on and you can't dispute its record.

The only way to get 40-60 is to make the boss machinist give you a *flat rate,* that is, fix a price for the labor to be done, then at least you'll know in advance what you'll have to pay and this way is always the cheapest in the end. Of course if he won't make a flat rate then you'll have to do like the other three-fourths of the car owners, and this is to suffer in silence.

Then there are the parts needed to make the repairs and here again unless you know exactly what the re-

placements are and what they cost, your bill will be inflated until you feel like going straight up and wish all the others would go straight down. And now I'll turn you over to some kindly disposed garage foreman for your shop repairs.

Work on the Front Axle.—When the front axle gets bent it should be straightened cold, though the common practice is to heat it and then straighten it, which is much easier. If the axle is broken it can be welded together cheaper than you can buy a new one.

Straightening the Frame.—If you should be so careless as to let some other car run into you and the frame of your car is bent it can be straightened by heating it with an *oxy-acetylene* torch and hammering it back into shape. Both the axle and frame are made of heat-treated steel and when they are heated to be straightened they are never quite as strong as before.

Repairing the Radiator.—When a radiator is jammed and leaks badly it takes a radiator specialist and a shop where there is a tank of water and an air compressor to test it and then a bath of melted solder to dip it in in order to get a really satisfactory job done.

Timing the Valves.—To time the valves of an engine so that it will deliver its maximum power is generally a job that should be intrusted to an automobile machinist who knows his business. Especially is this true if your engine is a 6, 8 or a 12 cylinder model, for it requires a pretty intimate knowledge of valve timing to do it the right way.

Adjusting the Connecting Rod Bearings.—The

oil must be drawn off and the oil pan taken off of the engine so that the crank shaft and connecting rod can be reached. The connecting rod bolts have to be loosened and one or more of the thin metal strips, called *liners,* or, in the parlance of the machinist, *shims,* must be taken out from between the *bearing caps*—an equal number from both sides—until the proper adjustment is had. To make the crank-pin of the shaft fit the bearings accurately the latter must be *scraped* and this is a job that takes a real machinist the best part of a day to do.

The bearings must not be made too tight, but the nuts on the bolts which hold them together must be put on tight or there may be a couple of hundred dollars' worth of damage done in a couple of seconds. New bearings can be bought already made, so don't let a machinist tell you that he has to cast them.

Adjusting the Crank Shaft Bearings.—Always have a machinist adjust the crank shaft bearings because it is a most particular job. The oil pan must be taken off as before and the flywheel jacked up; the nuts must be unscrewed from the bearing caps and enough shims taken out on both sides to bring the caps close enough together to make them fit the crank shaft *journal,* and if needs be these must be scraped.

The bearings must not be too tight, but they must be bolted in tight. New bearings can be bought from the maker of your car. Should your engine begin to knock, if it is the *wrist-pin,* or *gudgeon pin* to give it its right name, connecting rod or the main bearings that cause it, you must have them taken care of at once.

Regrinding and Reboring Cylinders.—When a cylinder becomes worn by the angular pressure of the piston on its lower stroke, or it has been *scored* by a broken piston ring, it must be reground or rebored, or else a whole new block of cylinders must be put in, and the latter is often the cheapest and it is certainly the best way.

To regrind the cylinders an *emery wheel* so mounted that it is carried automatically around on the inside wall of the cylinder is used. To rebore the cylinders, either an *engine lathe* or a *reboring machine* is used. Some repair shops have what is called a *reboring tool* for reboring small cylinders and with which a very ordinary mechanic can do quite an accurate job.

Don't let anyone induce you to have the cylinders reground or rebored unless he shows you with a pair of *micrometer calipers* that they actually need it, and then figure the cost of the job as against a new block of cylinders.

Rebrazing Loose Parts.—By *brazing* is meant the joining of two pieces of metal with *hard solder*. The *rear axle housings* and *torsion tubes* of many cars are riveted and then brazed. Once in a while the vibration of the rear axle jars the brazing loose and this not only lets the grease leak out, but if it is not rebrazed at once the rivets are liable to give way under the strain and then the housing will have to be re-riveted.

Welding Broken Parts.—When a large metal part breaks it is usually much cheaper to have it *welded* than it is to buy a new one. By welding is meant the joining of two pieces of metal by heating them until

they are soft and then forcing the ends or edges of the pieces together.

There are two processes used for welding and these are (1) the *oxy-acetylene* process and (2) the *electric* process. In the oxy-acetylene process acetylene gas and oxygen gas are mixed in a torch and the flame produces a white, or welding heat. In the electric process a heavy electric current heats the metal at the junction to the welding temperature. In either process when the welding temperature is reached pressure is applied and this joins the soft parts into a complete union, or *weld* as it is called.

Rims, brake levers, crank, propeller and cam shafts, connecting, steering, brake and extension rods, step and lamp brackets, steering levers and knuckles, axles and yokes, valve heads to stems, anchor bolts, broken castings and forgings of any kind, and cracked cylinders and jackets can all be welded as good as new, nearly.

Putting New Leather on the Clutch.—When the leather on the clutch is worn down so far that it will not hold after it has been fully expanded by the adjusting nuts, it is time to have a new leather put on, and it takes a good man to do a good job.

As the old leather is riveted to the steel cone the rivets have to be cut off inside with a cold chisel and when a new leather is riveted on, it must not only hold tight but it must be perfectly smooth and the rivets must be sunk lower than the surface of the leather, a *counterbore* being used to enlarge the holes. A new leather cut to shape and size can be bought from the factory.

Fixing the Steering Gear.—The steering gear

will remain in adjustment for a long time, but finally it will begin to show the effects of wear and the steering wheel will have too much play or *back lash* as it is called; it is all right for a steering wheel to have a couple of inches play, for it steers better than when it only has a play of about one inch.

To adjust the play the front part of the car has to be jacked up and the adjusting nuts can then be tightened up. The bushing must also be adjusted and there are a lot of other things that must be done; consequently it is the better way to let a man who draws a salary as an expert fix it for you.

Taking Care of the Universal Joints.—It is not very often that the pins of the universal joints break, for the shearing stresses to which they are subjected are carefully calculated and to this is added a large safety factor. After long usage, however, the bushings may become worn, when of course they should be renewed.

About the Transmission Gears.—The transmission ought to be looked into at least every season and the gears cleaned.

If any of the gears are worn too much or are *stripped* new ones will have to be put in. In ordering new gears try to get *nickel heat-treated steel* gears, as those made of carbon steel and *case hardened* will give you poor service. Occasionally the linkage between the gear shift lever and the *sliding block* gets out of adjustment and this must be attended to.

A Twisted or Broken Propeller Shaft.—If the shaft is of ordinary carbon steel it may be sheared off

through some defect in the steel, but if it is of vanadium steel it will twist when the stress becomes too great. If the shaft is broken it can be welded together, but if it is twisted it can easily be straightened and it should be straightened cold or its hardness will be destroyed.

Testing the Differential.—The differential should be tested every season and you can do this yourself as follows: jack up both rear wheels so that they will run freely; place the gear shift lever in one of the speed notches; now release the emergency brake and turn one wheel one way and one the other, and if they turn in opposite directions freely it is all right, otherwise it is all wrong and must be overhauled.

If the differential is kept well lubricated it will be a long time before any play or backlash in the gears will be noticeable. The joint pins in the propeller shaft may wear down until they get loose and this will produce a knock in the differential. New pins cost very little, but the cost of the labor of putting them in will make the bill large enough to suit you. Should the gears strip have chrome nickel heat-treated steel gears put in if possible.

Relining the Brakes.—When the brake linings get worn so that they will not hold they must be replaced. The brake linings are made of asbestos fiber and this is riveted onto the steel brake bands. To take off the old brake linings the rivets have to be cut off with a cold chisel. The Johns-Manville Company, 41st Street and Madison Avenue, New York, makes a good line of brake linings.

Overhauling Your Car.—And now finally to keep

your car good as new and in fine running order the engine should be overhauled every three years. This means that you will put your car in the hands of an automobile machinist and he will go over every part of it carefully and see that every nut is tight, that all the parts are in adjustment and that all the bearings are in good shape.

The best time to have your car overhauled is in the winter, for then the repair shops are not so busy, hence the machinists will take more pains and the job will cost you less than if you wait until the *vernal equinox,* to wit, the coming of spring, to do it.

CHAPTER XII

HOW TO RUN YOUR CAR AT THE LEAST COST

To get the best service and the most mileage out of a car at the least possible cost you must begin to think about economy before you ever buy one. And then after you become the proud possessor of the coveted machine you must take the proper care of it, for eternal vigilance is also the price of economical operation.

On Extra Seating Capacity.—I didn't mention it over there in the first chapter on *How to Buy a Car,* because it was too near the front of the book for such an elemental and sordid suggestion and I don't want you to follow it unless you really have to.

But to get down to brass tacks one of the most expensive things that the ordinary motor car owner goes up against is to have a five, or a seven seated car when there are only two or three in the family. To haul from one to five extra passengers every time you take a spin or make a trip is a mighty costly piece of business and to have the extra seating capacity and then not do it makes a fellow feel pretty cheap and puts him in the *tightwad* class among his less fortunate neighbors.

If yours is a family of two or three it will save you more dollars than you would ever believe to have a car just large enough to seat them and then there are

no hard feelings, for no one expects you to do the handsome thing. Of course if you have a safety deposit box full of first and refunding 5 per cent gold bonds, Series A of the United States Rubber Co., and you are a philanthropist to boot, why then my argument falls flat.

What Speed Economy Means.—Over in the first chapter I also told you to drive your car to the limit for the first three months, but you will recollect that I did not say to drive it like a speed demon.

To speed up your car to 30 miles an hour or faster means that you will increase the cost of running it rather than to economize in its operation; indeed, it is far better to keep an even speed of say 20 to 25 miles an hour, especially if your car is a small one.

Running at high speed is not only hard on the car but it very often results disastrously, and for the average person it is neither conducive to pleasure nor to economical motoring.

How Tire Economy Is Had.—*The Size of Tires to Use.*—It is the cheapest way in the long run to use the largest casings that can be put on the wheels of your car.

Suppose as an illustration the wheels of your car take 32 x 3½ inch casings, then it will take 32 x 4 inch casings, and though the latter cost a little more, they will stand up under the wear and tear at least a third better.

By all means use the oversize on the rear wheels where the friction is the greatest. When the rear casings are pretty well worn transfer them to the front wheels where the friction is not nearly as great. And

always use a *non-skid* tread because the tractive effort is better.

The Proper Inflation of Tires.—Always keep the tires pumped up hard; it is when the tires are soft that

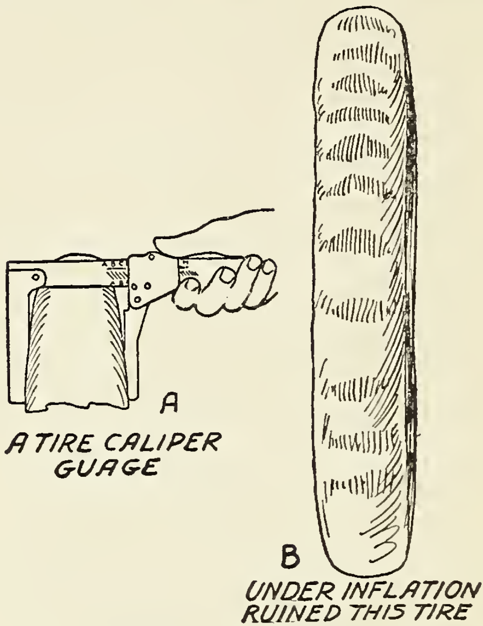


FIG. 74.—A and B Tire inflation.

the rubber is cut away, and punctures and blowouts happen. Keep your tires inflated with a pressure of 20 pounds per square inch of cross section when they are hot, that is, a 4-inch tire should be pumped up to 80 pounds pressure. The best way to gauge the pressure is with a *tire caliper,* see Fig. 74, as this is easier to use and more accurate than a pressure gauge. Stick

to the following inflation table, winter and summer, and your tires will be right:

3 inch tires	60 pounds pressure
3½ inch tires	70 pounds pressure
4 inch tires	80 pounds pressure
4½ inch tires	90 pounds pressure
5 inch tires	100 pounds pressure
5½ inch tires	110 pounds pressure
6 inch tires	120 pounds pressure

If you have neither tire calipers nor pressure gauge, pump up the tires until they stand up straight under the weight of the car when there are no passengers in it. And don't forget that 90 per cent of all tire trouble is due to under-inflation.

How to Be Good to Your Tires.—As you value a two-dollar bill, don't put the brakes on suddenly, for this locks the wheels, slides them over the roadbed and scrapes off both the rubber and fabric as shown at A in Fig. 75.

And here are a few extra *don'ts* which, if you heed them, will save you many extra dollars. (1) Don't drive fast around corners and (2) don't start or stop too quickly, for the first causes the wheels to skid, and the second makes them slide. (3) Don't let your brakes get out of adjustment or an extra strain will be put on one of the tires and (4) don't let your wheels get out of alignment or your tires will soon be ground to pieces.

(5) Don't throw in your clutch too quickly as this puts a great strain on your tires and (6) don't drive in the car tracks as they scrape the rubber off the sides

of the casings. (7) Don't let oil stay on the tires, as it rots them, and (8) don't let them stand in the water for the same reason. (9) Don't let the tires remain in a place that is more than 55 or less than 40 degrees Fahrenheit, as both heat and cold deteriorate the rubber, and (10) don't let the tires stay in the light when

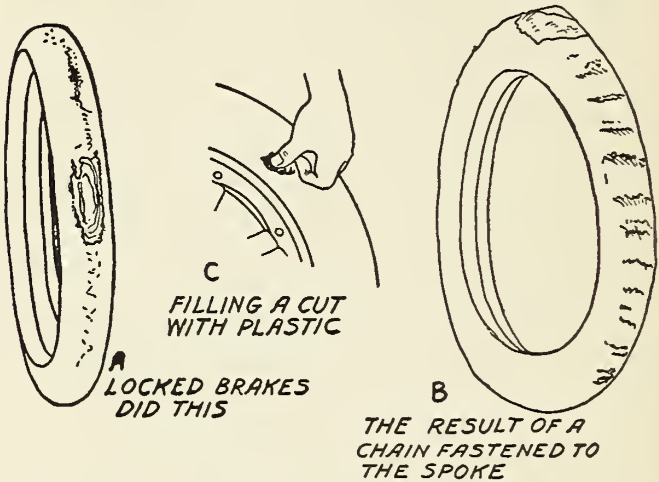


Fig. 75.—Abused tires.

they are not to be used for some time, for this also has an untoward effect on the rubber.

(11) Don't let the weight of the car rest on the tires if it is not in use, but jack it up, and (12) when you take the tires off wrap the casings in strips of paper, muslin or burlap. (13) Don't take the inner tubes out of the casings when putting them away, but pump enough air into them to keep them round, and (14) don't put on the tires until you have scraped off all the rust,

cleaned the rims thoroughly and given them a coat of shellac.

On the Use of Chains.—Any chain will injure a tire but some chains are more injurious than others. Never fasten the chains to the spokes, but let them run loosely, for the least injury results from chains that have play enough to work around the tire as this distributes the strain to all parts equally. See B, Fig. 75.

Keep Your Tires in Repair.—(1) Inspect the tires after every run for small cuts and fill them with plastic as shown at C; (2) cuts, bruises and punctures of any size should be immediately vulcanized and (3) when you put on the tires use plenty of *soapstone* between the tubes and the casings, as this greatly lessens the friction between them and keeps them cool.

About Buying New Tires.—Nearly all tire companies guarantee their tires for 5,000 miles against blowouts, blisters and rim-cutting, but usually there is so much red tape and so many strings to the guarantee that it isn't worth anything. The best guarantee is to buy good tires in the first place.

Now there are many good tires on the market, but from experience I can say use Goodrich tires—especially their *Silvertown cord* tires—or United States tires and you can't go wrong.

Practicing Economy in the Water System.—To keep the engine at a temperature where it will work with the highest efficiency, see that the radiator is full of clean water; there is a strainer in every radiator filler and always pour the water through it.

Drain off the old water once a month through the drain

cock, flush out the radiator with the garden hose every three months and clean out the water jackets every year. Water system economy costs nothing but it will save you a great deal.

How Fuel Economy Is Obtained.—There are three things that make for fuel economy, that is, the highest mileage per gallon of gasoline used, and these are (1) to always use a good uniform grade of gasoline; (2) to have the carburetor adjusted to give the right fuel mixture, and (3) preheating the gasoline or the fuel mixture.

To get a good uniform grade of gasoline buy either Gulf, Texas or Standard Oil Company's gasoline; there are doubtless other equally good grades on the market, but I know the ones I have named above to be all right. If there is an agent in your vicinity who sells the make of carburetor you are using, have him adjust it should the engine seem to fall off in power. Heating the gasoline or the fuel mixture is the great economizer, so have a preheater put on your carburetor.

How to Secure Ignition Economy.—Whether you use a battery or a magneto, see that the timer is in adjustment and keep the spark plugs clean.

If the ignition current is generated by a magneto and the spark will not jump a full ⅛ inch, send the magneto to the nearest service station of the maker and have it fixed. A weak spark will cause much loss of power.

When the battery system is used go to bed with the battery on your mind. If you would hold whatever small change you have, then (1) keep the plates covered by the battery solution, (2) keep the battery as fully

charged as possible and (3) have the specific gravity of the battery from 1.275 to 1.300; as long as the battery is fully charged it can't freeze, and when you put your car away either turn the battery over to a service station or give it a fresh charge once a month without fail. By remembering these things you will have ignition economy with a big E.

How Oil Economy Is Worked.—The necessity for using the best oils and grease was pointed out in the chapter on *How the Oiling System Works.* Above everything else see to it that your car is properly lubricated and by this I not only mean that you should use only the very best quality of lubricants, but that you should never make a run until every working part of the car is fully supplied with oil and grease.

Your instruction book will tell you what oils and grease you should use and your lubricating chart will tell you where, when and how to use them. If you would save money and trouble do these three things, (1) lubricate; (2) lubricate and (3) lubricate. And don't forget that when running over country roads much more oil is used than on city pavements and consequently supply the engine with additional oil and turn up the grease cups often.

About Saving on Your Starting and Lighting System.—As you have seen in Chapter IX there is very little chance of saving anything as far as the starting and lighting systems are concerned, except the storage battery, the economical operation of which was briefly described under the caption, *How to Secure Ignition Economy.*

The dynamo for charging the battery and the motor for starting the engine are so constructed that it is very seldom anything gets the matter with them.

How to Practice Engine Economy.—When you get your car don't try out the engine by *racing* it, that is accelerating it when the car is stopped and running it spasmodically at high speeds. There is never a time when you need to do this and it causes a lot of wear that you will be called on to pay for a couple of years later.

Your Private Economy Service Inspection.—By this I mean that you should institute a service inspection of your own for the fulfilment of these two ideas, (1) to keep your car tuned up to concert pitch and (2) to effect as large a saving in its operation as possible. At the end of the first 500 miles and every 1000 miles thereafter inspect the following items:

TABLE OF INSPECTION ITEMS

1. Lubrication of all points shown on chart.
2. Clean out oil reservoir; refill with new oil.
3. See that oil pump works; no leaks.
4. Oil reservoir gasket.
5. Examine for carbon; spark plugs.
6. Adjust tappets and check clearance.
7. Grind valves if needed.
8. Valve cover plate gasket oil tight.
9. Water pump glands tight.
10. Pump shaft and coupling secure.
11. Oil hood lacing; hood sockets tight.
12. Clutch in adjustment.
13. Adjust fan belt tension and inspect fan bearings.
14. Carburetor throttle adjustment.

15. Motor secure in chassis; all motor bolts.
16. Transmission main shaft end play.
17. Rear axle pinion adjustment.
18. Rear axle drive shafts tight.
19. Rear wheels tight on taper.
20. External brake adjustments.
21. Internal brake adjustments.
22. Universal joint covers tight.
23. Steering worm thrust adjustment.
24. Steering worm wheel end play.
25. Steering arm tight on taper.
26. Control levers on steering wheel.
27. Drag link adjustment.
28. Tie bar adjustment tight.
29. Front wheel bearings adjustment.
30. Tighten properly spring clips.
31. Spring shackle bolts tight.
32. Lubrication of spring leaves.
33. Rims applied properly.
34. Body bolts tight.
35. Oil door hinges, locks and set bumpers.
36. Repair top curtain fasteners.
37. Clean car thoroughly.
38. Generator clutch alignment.
39. Generator bolts secure.
40. Starter adjustment secure.
41. All generator connections tight.
42. Clean lamp connectors.
43. Distributor head cleaned.
44. Rotor button tension moderate.
45. Ignition resistance in circuit.
46. Examine contact breaker.
47. Test circuit breaker.
48. Commutators in good condition.
49. Check charging rate.
50. Examine water cooling system.
51. General condition of engine.

52. Battery terminals and ground connections tight and clean—specific gravity correct.
53. Inspect spring bolts and rangers. Pry leaves apart and apply graphite grease.

Your Company's Service Inspection.—Some of the companies have established service inspection stations where you can take your car and have an experienced man make the inspection scheduled in the above list of items every month and without cost to you.

The company whose car you own guarantees it on the condition of adequate maintenance on your part. If a part breaks because of a defect the company will replace it without cost to you, but if it breaks through any fault of yours you have to pay for the replacement.

Keeping Your Car Spick and Span.—Not only do you want your car to run like a real automobile and at the smallest cost for up-keep, but if you are like the other 999 per cent of owners it must have *class* as well.

Cleaning the Top.—To keep a car looking its very best it must be washed in a certain way. Always clean the top first. A *mohair* top can be brushed off while a *pentasote* top should be sponged off with clean tepid water in which a little ammonia or castile soap has been added and then rub it dry with a chamois skin.

Washing the Body.—Next wash the body of the car and to get the dirt and mud off without marring it let a gentle stream of water from the garden hose, from which the nozzle has been taken off, flow all over it, beginning at the top and working down. Wait half an hour for it to soak into the dirt and go all over the car

again the second time with the hose, when the dirt will be entirely washed away.

Never rub the painted surface of the body with a *chamois,* or anything else, until every particle of dirt has been washed off. If there are grease spots on the body wash them off with Ivory soap and water applied with a chamois and rinse the latter frequently; then wash off the soap with the hose.

This done soak a soft chamois in clean water, wring it dry and wipe all of the surface from the top down—never with a circular motion—with the slightest pressure and let the film of water that remains evaporate.

Washing the Running Gear.—Finally wash the running gear, the mud guards and hood with cold water before the mud has had time to dry on. Wash off the film of grease with Ivory soap and wash off the suds immediately; should soap fail to cut the grease use *fuller's earth* and water. Wash off and dry with a chamois as before. Have a chamois for the body and one for the running gear and never switch them. By following the above directions your car will look almost like new for a long time to come.

Some Useful Recipes.—*A Good Body Polish.*—This polish will make an old body look as if it had just come from the painters. Mix 1 gallon of turpentine, 1 pint of paraffin oil, 3½ ounces of citronella oil and 1½ ounces of cedar oil. Use a little at a time and rub it until it is thoroughly dry. This is far better than mixtures of linseed oil and kerosene or linseed oil and turpentine.

A Fine Leather Polish.—Beeswax dissolved in tur-

pentine to the consistency of thin cream makes a fine polish for leather upholstery.

To Clean Cloth Upholstery.—Beat the cushions to get out the dust; grease or oil can be removed by scouring it with chloroform and it will not leave a circle after it evaporates. Ivory soap and water put on with a woolen cloth can also be used.

To Clean Nickel Plated Parts.—Rub them up with lamp-black, or powdered rotten stone, mixed with a little oil and put on with a soft flannel rag.

To Clean Aluminum.—Wash the aluminum foot boards with a strong solution of hyposulphate of soda and water, which will dissolve the aluminum tarnish, and then wash off with water and dry.

To Clean Lamp Reflectors.—Don't touch the lamp reflectors until they become too dull through long service to be useful. When they get dusty blow the dust out. Polish old reflectors on which there are spots or which are tarnished, with *red rouge* and put it on with a chamois skin dampened with alcohol. Wipe this off with another chamois and dry rouge which will give the reflector a high polish.

In polishing a reflector press very lightly on it and give the chamois a circular motion. Old reflectors can be re-plated with silver and burnished, when they will be as good as new.

To Clean Off Road Oil.—Rub with a soft rag dipped in crude oil; after it is dry dampen another rag with water, sprinkle on a few drops of alcohol; rub off the polished film and give it a final polish with a dry rag.

To Clean Off Grease on Frame and Brakes.—Rub off

with a rag dipped in clear turpentine and polish with crude oil. Don't let the turpentine stay on any longer than necessary.

To Clean Windows.—Wash with equal parts of soapy water and wood alcohol.

To Clean Celluloid.—Wash with a piece of soft cheese cloth dipped in vinegar.

A Good Oil for Door Hinges.—Mix a little powdered graphite with linseed oil.

To Keep the Windshield Dry.—You can prevent the drops of water from clinging to the windshield in rainy or snowy weather by going over the glass with a solution made of 1 ounce of water, 2 ounces of glycerine and 1 dram of salt. Dampen a piece of gauze with it and wipe the glass from the top toward the bottom with it.

Storing Your Car for the Winter.—Should you want to store your car for several months, run it into the garage, then drain all the water from the cooling system, take off the radiator cap and run the engine until it is thoroughly heated so that every particle of water that may be pocketed in it is evaporated.

Drain off the gasoline; take off the tires, clean the rims and give them a coat of shellac varnish. Put up the top; fasten on all of the curtains and cover the whole top and body with a slip made of muslin.

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